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Volume XII

Edited by

CARLETON REA and J. RAMSBOTTOM

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THE ARUNDEL FORAY.

THE 1926 Spring Foray was held at Arundel from Friday evening, May 21st, to Tuesday morning, May 25th, with headquarters at the Norfolk Hotel. On Saturday, May 22nd, a start was made about 10.0 a.m. and the whole day was spent in working through Paine's Wood and Rewell Wood under the guidance of the Head Forester of the Norfolk estate. These woods lie to the west of Arundel, and consist mainly of oak and sweet chestnut, with some beech and occasional conifers. Large fungi were scarce, but a fair collection of the lower Basidiomycetes and of micro-fungi was obtained. Mr Pearson secured *Tulasnella* (*Gloeotulasnella*) *cystidiophora* v. Hoehn. & Litsch., which will be described by him in a separate paper. Other interesting finds were *Collybia leucomyosotis*, *Peniophora longispora* (a very fine specimen), an unusually large specimen of *Ganoderma applanatum*, *Eichleriella spinulosa*, *Bourdotia Eyrei** with its characteristic red coloration of beech wood, and *Hypocrea fungicola* on an old specimen of *Polyporus betulinus*. In the nursery some dying Scots pines were accounted for by the finding of rhizomorphs of *Armillaria mellea*. *Ustulina vulgaris* was abundant on standing beeches both in these woods and in Arundel Park. The route followed ended up at the north end of Rewell Wood and Arundel Park, where tea was obtained at Whiteways Lodge.

On Sunday the greater part of the collecting was done amongst parasitic fungi in various gardens in Arundel. In the morning some of the members explored the large kitchen garden and the flower garden of the Norfolk Hotel, and secured a number of species of interest to plant pathologists. *Uromyces Betae* and *Ramularia beticola* were found to be abundant on old leaves of Spinach Beet, while a heap of old cabbage stumps provided material of *Gibberella cyanogena*. Among diseases which do not find a place in the following list were noted Reversion in black currants and *Bacterium Delphinii* on larkspurs.

On Sunday afternoon, by kind permission of Her Grace the Duchess of Norfolk, the party was conducted over the gardens of Arundel Castle by the estate agent, Mr G. F. Drake. Near the entrance gate was noted a plane tree badly attacked by *Gnomonia veneta*, and a lime with leaves spotted by *Gloeosporium Tiliae* var. *maculicola*. Later on *Phomopsis Sophorae* was

* This fungus was unfortunately redescribed by Bresadola (Ann. Myc. XVIII (1920), 48), under the name of *Gloeocystidium croceotingens*, with an incorrect citation of the present author (who had sent him specimens) as authority. The fungus is an undoubted *Bourdotia*, but belongs, as Bourdot has pointed out, to the series of *Gloeocystidium caesiocinereum*, *Sebacina cinerea*, etc.

obtained from dead twigs of a fine *Sophora japonica*, and *Diplodia laurina* Sacc. from dead twigs of *Laurus nobilis*. The latter fungus appears to be a new record for this country. In the kitchen garden the most interesting find was *Sclerotinia Mespili* on medlar, the attack being very noticeable on account of the browned leaves, and the curious sweet odour of the conidial stage of the fungus.

On Monday Batworth Park Plantation, lying to the east of the river Arun, was worked. The ground here was fairly damp, and the wood, although small, proved more productive than most of the ground traversed on the Saturday. Ash occurred intermixed with oak, and fallen branches of ash provided such species as *Cryptosphaeria eunomia*, and large specimens of *Daldinia concentrica*. Other finds were *Radulum quercinum*, *Heterochaetella crystallina*, *Tulasnella violea*, and *Cercospora Rubi* Sacc., the last a new record for Britain. At the end of the day the party was entertained at tea by Mr and Mrs J. Fowler of Sefton Place. There a walk round the garden provided a few additional records. In particular the interest of pathologists present was aroused by the finding of abundant material of *Pseudoperonospora Humuli* on hop plants in a hedge.

The meeting concluded with hearty votes of thanks to the Duchess of Norfolk and to her agent Mr Drake for facilities given for working on the estate, and to Mr Fowler for his assistance in general arrangements.

The following list includes all the species which have been determined, and the Secretary is indebted to all the members present for assistance in compilation. The record of *Ligniera Junci* was forwarded by Mr W. R. I. Cook, who found it on roots of some water plants taken by him.

Species marked with an asterisk are new to Britain and will be described.

Complete List of Species gathered during the Foray.

R. = Paine's and Rewell Woods; *A.* = Arundel Castle gardens and other gardens in Arundel; *B.* = Batworth Park Plantation.

HYMENOMYCETES.

Armillaria mellea (Vahl.) Fr., rhizomorphs only, *R.*, *B.*
Laccaria laccata (Scop.) B. & Br., *R.*
Collybia platyphylla (Pers.) Fr., *R.*, leucomyosotis Cooke & Smith, *R.*
Mycena filopes (Bull.) Fr., *B.*
Lactarius pubescens Fr., *R.*
Marasmius peronatus (Bolt.) Fr., *B.*, dryophilus (Bull.) Karst., *R.*
Nolanea proletaria Fr., *R.*, *B.*
Pholiota praecox (Pers.) Fr., *B.*
Galera hypnorum (Schrank) Fr., *R.*, *B.*
Tubaria furfuracea (Pers.) W. G. Smith, *R.*, *B.*
Cortinarius (Hydrocybe) leucopus (Bull.) Fr., *R.*
Stropharia aeruginosa (Curt.) Fr., *B.*

Hypholoma fasciculare (Huds.) Fr., *R.*, *A.*, *B.*, velutinum (Pers.) Fr., *A.*
Psilocybe foenisecii (Pers.) Fr., *R.*
Coprinus atramentarius (Bull.) Fr., *B.*, picaceus (Bull.) Fr., *R.*, micaceus (Bull.) Fr., *R.*, plicatilis (Curt.) Fr., *R.*
Panaeolus sphinctrinus Fr., *R.*, campanulatus (Linn.) Fr., *R.*
Psathyrella disseminata (Pers.) Fr., *B.*
Boletus elegans (Schum.) Fr., *R.*, *B.*
Lenzites betulina (Linn.) Fr., *R.*
Polyporus lentus Berk., *R.*, betulinus (Bull.) Fr., *R.*, squamosus (Huds.) Fr., *B.*, adustus (Willd.) Fr., *A.*
Fomes annosus Fr., *R.*, *B.*, ferruginosus (Schrad.) Massee, *R.*
Ganoderma applanatum (Pers.) Pat., *R.*, *A.*
Polystictus versicolor (Linn.) Fr., *R.*, *B.*
Poria hymenocystis B. & Br., *B.*, obducens (Pers.) Fr., *B.*
Daedalea quercina (Linn.) Fr., *R.*, *B.*
Merulius corium (Pers.) Fr., *R.*
Irpex obliquus (Schrad.) Fr., *R.*, *B.*
Radulum quercinum Fr., *B.*
Odontia farinacea (Pers.) Quél., *B.*
Stereum hirsutum (Willd.) Fr., *R.*, *B.*, purpureum (Pers.) Fr., *R.*, *A.*
Hymenochaete rubiginosa (Dicks.) Lév., *R.*
Corticium laeve (Pers.) Fr., *R.*, *B.*, niveo-cremeum v. Hoehn. & Litsch., *R.*, *B.*, Sambuci (Pers.) Fr., *B.*, botryosum Bres., *R.*, confluens Fr., *R.*, *B.*, confine Bourd. & Galz., *R.*, *B.*, porosum Berk. & Curt., *R.*, praetermissum (Karst.) Bres., *R.*, *B.*
Peniophora pallidula Bres., *R.*, longispora (Pat.) v. Hoehn. & Litsch., *R.*, cremea Bres., *R.*, velutina (DC.) Cooke, *R.*, *B.*, setigera (Fr.) Bres., *R.*, *B.*, hydnoides Cooke & Massee, *R.*, *B.*, cinerea (Fr.) Cooke, *R.*, *B.*, laevigata (Fr.) Massee, *R.*, quercina (Pers.) Cooke, *R.*
Auricularia auricula-Judae (Linn.) Schroet., *B.*, mesenterica (Dicks.) Fr., *B.*
Tremella mesenterica (Retz.) Fr., *B.*
Exidia glandulosa (Bull.) Fr., *B.*, Thuretiana (Lév.) Fr., *R.*, *B.*
Eichleriella spinulosa (Berk. & Curt.) Burt, *R.*
Heterochaetella crystallina Bourd., *B.*
Bourdotia Eyrei Wakef., *R.*
Tulasnella violea (Quél.) Bourd. & Galz., *B.*, *(Gloeotulasnella) cystidiophora v. Hoehn. & Litsch., *R.*

UREDINEAE.

Uromyces Ficariae (Schum.) Lév., *B.*, Fabae (Pers.) de Bary, *B.*, Betae (Pers.) Tul., *A.*, Scillarum (Grev.) Wint., *R.*, *B.*, Dactylidis Otth. (aecidium), *A.*
Puccinia Violae (Schum.) DC., *R.*, Malvacearum Mont., *A.*, Saniculae Grev., *R.*, obtegens (Link) Tul., *A.*, Primulae (DC.) Duby, *B.*, Vincae (DC.) Berk., *A.*, Menthae Pers., *A.*, Buxi DC., *A.*, Caricis (Schum.) Rebent., *A.*, glumarum (Schum.) Eriks., *B.*, Phragmitis (Schum.) Koern. (aecidium), *B.*, Poarum Niels. (aecidium), *A.*
Phragmidium Rubi (Pers.) Wint., *B.*, violaceum (Schultz) Wint., *R.*, *B.*
Pucciniastrum Circaeae (Schum.) Schroet., *B.*, Epilobii (Pers.) Otth., *R.*
Milesina Scolopendrii (Fckl.) Jaap, *A.*
Melampsorella Symphyti (DC.) Bubak, *A.*

USTILAGINEAE.

Entyloma Ranunculi (Bon.) Schroet., *R.*

PYRENOMYCETES.

Podosphaera oxyacanthae (DC.) de Bary, *R.*, leucotricha (E. & E.) Salmon, on apple and pear, *A.*
Erysiphe Polygoni DC., on *Aegopodium*, *A.*, cichoracearum DC., on *Symphytum*, *B.*
Uncinula Aceris Sacc., *B.*

Phyllactinia corylea (Pers.) Karst., on *Cornus*, *B*.
Gibberella cyanogena (Desm.) Sacc., *A*.
Nectria cinnabarina (Tode) Fr., *A*., galligena Bres., on apple and pear, *A*., episphaeria (Tode) Fr., *B*.
Hypocrea fungicola Karst., on *Polyporus betulinus*, *R*.
Leptospora spermoides (Hoffm.) Fckl., *B*.
Stigmatea Robertiani Fr., *R*., *A*.
Mycosphaerella maculiformis (Pers.) Schroet., *R*., brassicicola (Duby) Lindau, *A*., Fragariae (Tul.) Lindau (conidia), *A*., hedericola (Desm.) Lindau, *B*.
Venturia inaequalis Aderh. (conidia only), *A*., pirina Aderh. (conidia only), *A*.
Leptosphaeria Rusci (Wallr.) Sacc., *R*., acuta (Moug. & Nestl.) Karst., *R*., *B*.
Gnomonia veneta (Sacc. & Speg.) Kleb. (conidia), *A*.
Cryptosphaeria eunomia (Fr.) Fckl., *B*.
Diatrypella quercina (Pers.) Nke., *R*., *B*.
Diatrype Stigma (Hoffm.) de Not., *R*., *B*.
Hypoxylon coccineum (Bull.) Fr., *R*., *A*., *B*.; multiforme Fr., *R*.
Daldinia concentrica (Bolt.) Ces. & de Not., *R*., *B*.
Ustulina vulgaris Tul., *R*., *A*.
Xylaria Hypoxylon (Linn.) Grev., *B*.
Phyllachora graminis (Pers.) Fckl., *B*.

HYSTERIACEAE.

Dichaena quercina Fr., *R*., *B*.
Rhopographus Pteridis (Sow.) Wint., *R*.

DISCOMYCETES.

Aleuria ampliata (Pers.) Gill., *R*.
Peziza aurantia Pers., *B*.
Ciliaria scutellata (Linn.) Quél., *B*.
Coprobia granulata (Bull.) Boud., *B*.
Ascobolus stercorarius (Bull.) Schroet., *B*.
Exoascus deformans (Berk.) Fckl., *A*.
Orbilia xanthostigma Fr., *B*.
Sclerotinia cinerea Schroet., *A*., Mespili Schell., *A*.
Chlorosplenium aeruginosum (Oeder.) de Not., *R*., *B*.
Helotium herbarum (Pers.) Fr., *R*.
Dasyscypha virginea (Batsch) Fckl., *R*., *B*.
Arachnopeziza aurelia (Pers.) Fckl., *R*., *B*.
Mollisia cinerea (Batsch) Karst., *R*., *B*.
Pseudopeziza Trifolii (Biv.-Bern) Fckl., *B*.

PHYCOMYCETES.

Cystopus candidus (Pers.) de Bary, *A*.
Plasmopara nivea (Unger) Schroet., *A*.
Bremia Lactucae Regel, *A*.
Peronospora calotheca de Bary, *A*., parasitica (Pers.) Tul., *A*., alta Fckl., *A*.
Pseudoperonospora Humuli (Miy. & Tak.) Wilson, *A*.

PROTOMYCETACEAE.

Protomyces macrosporus Ung., *A*.

SPHAEROPSIDACEAE.

Phyllosticta hedericola Dur. & Mont., *R*., *B*.
Phoma acuta Fckl., *B*.
Phomopsis Sophorae (Trav.) Grove, *A*., cinerascens Trav., *A*.
Actinonema Rosae (Lib.) Fr., *A*.
Septoria Rubi West., *R*., Stellariae Rob. & Desm., *A*., Apii Bri. & Cav., *A*., Petroselini Desm., *A*.
*Diplodia laurina Sacc., on *Laurus nobilis*, *A*.
Gloeosporium Tiliae Oud. var. maculicola Allesch., *A*., concentricum Grev., *A*.
Discella strobilina (Desm.) Died., *A*.

HYPHOMYCETES.

Oidium Euonymi-japonicae (Arc.) Sacc., *A.*, alphitoides Griff.& Maubl., *R.*
Ovularia obliqua (Cooke) Oud., *R.*, *A.*, *B.*, Veronicae Fckl., *A.*
Botrytis cinerea Pers., *A.*, Tulipae (Lib.) Hopkins, *A.*
Rhinotrichum repens Preuss, *R.*, Thwaitesii B. & Br., *B.*
Ramularia Primulae Thuem., *R.*, Urticae Ces., *R.*, Taraxaci Karst., *A.*, brunnea Peck, *A.*, beticola Fautr. & Lamb., *A.*
Tilachlidium tomentosum (Schrad.) Lindau, on *Trichia varia*, *B.*
Vermicularia trichella Fr., *B.*
Bispora monilioides Corda, *R.*
Heterosporium gracile Sacc., *A.*
*Cercospora Rubi Sacc., *B.*

MYCETOZOA.

Ligniera Junci (Schwartz) Maire & Tison, *A.*
Lycogala epidendrum Fr., *A.*
Stemonitis fusca Roth., *B.*
Reticularia Lycoperdon Bull., *B.*
Arcyria denudata Wettst., *B.*
Trichia varia Pers., *B.*, Botrytis Pers., *B.*

NOTES ON THE CANKER FUNGUS (NECTRIA GALLIGENA BRES.).

By W. A. R. Dillon Weston, M.A.,

School of Agriculture, Cambridge.

(With Plates I–III.)

I. Shrivelled "Worcester Pearmain" Apples bearing Perithecia of *Nectria galligena*.

The occurrence of perithecia on "mummied" apples. During March, 1925, in an orchard of Worcester Pearmain apple trees, a shrivelled apple was found bearing the perithecia of *Nectria galligena*.

The trees were moderately attacked by "canker." Spurs and leaders showed both the *Fusarium* and perithecial stages.

In order to ascertain the prevalence of this fungus on the shrivelled fruits, seven hundred were collected from the trees and examined. Three apples only were found to be bearing perithecia (see Plate I, fig. 1): and in these the ascospores were mature.

Fungal flora of the fruits. Three hundred and seven apples were kept in a moist chamber for a few days and then the fungus most in evidence upon each was noted, as in Table I.

Table I.

Fungus	No. of apples showing the fungus
Nectria galligena (conidial stage—*Fusarium Willkommii**)	15
Fusarium sp.	42
Diaporthe perniciosa	96
Cytospora sp.	46
Botrytis sp.	14
Penicillium sp.	5
Venturia inaequalis	53
Monilia fructigena	36

Development of perithecia on apples kept under moist conditions. The shrivelled apples collected on March 26th were kept under moist conditions in large crystallising dishes until May 22nd. They were examined at various intervals to observe if perithecia had formed.

Observations are summarised in Table II.

Table II.

Date of observation	Apples showing perithecia	Remarks
April 20th ...	8	On some apples only one or two isolated perithecia were formed. The majority were immature
April 25th ...	2	
May 4th ...	0	
May 15th ...	10	
May 22nd ...	0	

Percentage of fruits with perithecia. Of the remaining seven hundred apples kept under the same conditions, twenty-six developed perithecia, so that, of the total number, forty-nine (or 7 per cent.) are presumed to have been infected with the "canker" fungus.

On March 10th, 1926, two hundred shrivelled apples were collected from the same orchard, and on two of these the perithecia of *Nectria galligena* were found.

In order to obtain some clue to account for the presence of perithecia upon shrivelled fruits, two series of experiments were conducted during 1925.

(1) Twenty-five shrivelled apples were collected from clean spurs.

(2) Twenty-five shrivelled apples were collected from "cankered" spurs.

Table III.

(i) *Apples from clean spurs.*

Date	April 25th	May 12th	May 15th	May 22nd	Remarks
No. of apples showing perithecia	0	0	0	7	Two apples shortly after being moistened showed the *Fusarium* stage

* *Fusarium Willkommii* Lindau = *Cylindrocarpon Mali* (Allesch.) Wollenw.

(ii) *Apples from "cankered" spurs.*

Date	April 25th	May 12th	May 15th	May 22nd	Remarks
No. of apples showing perithecia	0	4	11	14	Twenty-one apples shortly after being moistened showed the *Fusarium* stage

A possible explanation is that in series (ii) the mycelium had worked upwards through the spur and petiole to the shrivelled fruit and had there sporulated, eventually to produce the perithecial stage of the fungus.

In series (i) some free conidia may have been resting upon these apples and later on developed and fructified.

There is, however, a third possibility, viz. that the apple itself was at an earlier date infected with the "canker" fungus, that the apple rotted on the tree, and that when left in the laboratory under more advantageous conditions than would exist in the field, the final stage of the fungus was then produced. This presumes an apple rot occasioned by either (1) infection of the fruit with the conidial stage of apple canker (*Fusarium Willkommii* Lindau), or (2) infection of the fruit with ascospores of *Nectria galligena* Bres.

Inoculations. A seedling apple tree was inoculated during March, 1925, in three places, with ascospores obtained from the perithecia found occurring upon these shrivelled fruits. In November of the same year canker lesions were evident, but at the present date the growth of the fungus in the branch has been arrested. Inoculations were carried out by placing spores in drops of distilled water and introducing them to a small vertical cut in the bark.

II. An "Eye Rot" of Worcester Pearmain Apples caused by the Conidial Stage of *Nectria galligena* Bres.

Occurrence in Cambridgeshire. On July 7th, 1925, five hundred recently fallen Worcester Pearmain apples from this same Cambridgeshire orchard were collected and one was found to be rotting at the "eye." These were kept in the laboratory under dry conditions and examined three weeks later, when four of them showed a similar "eye rot."

At later dates, July 27th and 30th, five other apples were found similarly affected in this orchard; and subsequently many others were obtained.

Wisbech, Isle of Ely. Visits were made on August 6th and 12th to an orchard of Worcester Pearmains near Wisbech, and this disease was very evident on the fruits.

Both orchards are subject to "canker": very few old and deep-seated cankers are present, but girdling of first year wood, and lesions upon fruit spurs are very common.

An "eye rot" of pears* similar to the "eye rot" of apples has also been observed in this area, but has not been fully investigated. (See Section IV.)

Symptoms of this Disease. Diseased fruits ripen and colour prematurely, and are also characteristic in that the rot first starts at the calyx end.

The top of the apple then becomes slightly flattened, becoming more so as the disease progresses.

The skin and flesh of affected fruits are brown, but of a darker brown than rotting produced by *Penicillium* sp. Small raised pustules of the conidial stage (*Fusarium Willkommii* Lindau) of the canker fungus appear; these are of a dirty white colour, sometimes with a tinge of pink (see Plate I, fig. 2).

Distribution. Professor E. S. Salmon and Dr H. Wormald, Wye College, Kent, have recorded in the *Wye Journal* an apparently similar "eye rot" of Worcester Pearmain Apples. Their photographs of this disease are comparable with our own and it would appear that the two diseases are identical.

Their description of this disease is as follows:

"The diseased areas on the young apples obtained from Sussex in July bore closely aggregated pustules with very numerous conidia. The conidia are cylindrical, with rounded ends, usually slightly curved, and septate.

"The septa in the great majority of cases are 3–5 in number the 5-septate conidia being of very frequent occurrence.

"The dimensions vary considerably, the average size being about $50 \times 6\,\mu$, but conidia measuring from $25 \times 5\,\mu$ to $70 \times 7\,\mu$ were met with."

These conidia in size, shape and septation resemble those of the *Fusarium* which is the "summer stage" of *Nectria galligena*, the fungus producing "canker" in apple trees.

The second reference brought to my notice by Dr G. Pethybridge is: Ferdinandsen, C., "Ueber einen Angriff von Krebs

* Since this was written the "eye rot" of pears has been more fully investigated and Dr Wollenweber has confirmed the suggestion that the disease is due to *Cylindrocarpon Mali* (Allescher) Wr., stating, *in litt.*:

"It is interesting to note that in Denmark the apple variety 'Signe Tillisch,' in Baarn, Holland, the 'Present of England' apple and in England the 'Fertility' pear and probably a few other pear and apple varieties are some exceptions to the rule that the canker organism *Nectria galligena* usually does not rot the fruit. In German varieties of apple and pear the *Nectria* fruit-rot does not seem to occur to any extent, although my first finding of its conidial stage was in the endocarp of an apple at Dahlem, as published in *Grundlagen*, 1910, p. 174, under *Fusarium Willkommii* Lindau, and in *Phytopathology*, 1913, p. 226, under *Cyl. Mali* (All.) Wr."

A note appeared on this in the *Gardener's Chronicle* for Nov. 6th, 1926.

(*Fusarium Willkommii* Lind.) an Apfel und Birnfrüchten," *Angewandte Bot.* IV (1922), 173–184. It is there recorded that in Denmark in the autumn of 1919 a new disease of ripening apple and pear fruits appeared with which the conidial stage of *Nectria galligena* was associated: also that this disease of the fruits was capable of causing cankers on the twigs.

Experimental. Twelve Worcester Pearmain apples were inoculated with conidia of this fungus, and were kept in a large crystallising dish. After three to four days brown areas were apparent at the point of inoculation. Later the apples flattened out at this point and typical conidial pustules of the fungus appeared (see Plate III, figs. 1 and 2).

Apples found on July 7th were kept under moist conditions. Towards the end of August perithecia developed, but asci were not mature. The apples by then were completely rotten and saprophytic fungi had developed.

On August 7th apple trees in our experimental plot were inoculated with the fungus obtained from "eye rot" apples. Twelve inoculations were made and controls were left.

On August 15th, twelve branches of Worcester Pearmain trees in a different area were inoculated in the same manner. By November 4th typical "canker" lesions were apparent in both series and the conidial stage was reproduced upon them.

Cultures. Cultures were made from diseased fruits, the medium used being apple agar. Typical macro-conidia were formed, the spores being cylindrical, slightly curved, septate, and rounded at the ends.

The spores varied in size, the average being between 40–60 $\mu \times 5$–$5{\cdot}5\,\mu$. They were more often four- than five-septate. These measurements were taken from a culture three and a half months old.

Spore measurements from twigs artificially cankered, by infection with spores from "eye rot" apples, were generally between 56–70 $\mu \times 5$–$6\,\mu$, and five-septate. After three and a half months perithecia had not developed in culture but the mycelium had compacted into brownish red tufts.

Intensity of the disease. This was studied in an orchard of Worcester Pearmains in which we had carried out a series of spray trials to check "scab."* In these experiments the fruit was graded by hand. The first picking of fruit took place on August 20th, the second on August 25th, the main bulk being pulled on September 10th.

During the first picking, the fruit showing "eye rot" was weighed separately. The results obtained in these various plots are tabulated in Table IV.

* Journ. Min. of Agric. March, 1926.

For the first spraying lime sulphur was used at the strength of 1 in 30 and for the second spraying at 1 in 60. Where lead arsenate was added this was at the rate of 2 lb. of arsenate of lead paste to 40 gallons. The first spraying was carried out on May 13th, the second on June 3rd.

These figures are interesting in that they show that the spraying methods adopted to control apple "scab" were also effective in reducing "eye rot."

It should be noted, however, that these figures have no bearing upon the actual weight of fruit showing "eye rot" in this orchard. On the two subsequent pickings the disease was much less.

Table IV.

Row	Spray	Weight of clean fruit	Weight of fruit showing "eye rot"	% of "eye rot" to nearest whole number
		lbs.	lbs.	
2/3	Lime sulphur plus lead arsenate (twice)	31¾	2½	8
4/5	Ditto (once)	40½	6	15
6	Control	24	9¾	41
7/8	Normal Bordeaux (8 : 8 : 100) plus lead arsenate (twice)	4	0	0
13/14	Ditto (once)	25½	5½	22
15	Control	30	16½	55
16/17	Ex. Bordeaux (25 : 8 : 100) plus lead arsenate (twice)	14¾	2¼	15
18/19	Ditto (once)	15	1½	10
20/21	Prop. Bordeaux lead arsenate (twice)	13¾	2¾	20

The reason why greater weight of diseased fruit was obtained in this first picking is accounted for by the fact that the pickers pulled what they considered the more mature fruit. This was deceptive, because, in this variety a characteristic symptom is apparent earlier maturity and deep colouring.

III. The Wilting of Worcester Pearmain Blossom Trusses.

When the Worcester Pearmain trees in the above orchard were in flower, it was noticed that a few trusses on each tree were wilting.

On June 10th, twenty-five of these spurs were labelled and examined at intervals, and on July 30th, seventeen of them were showing "canker" lesions.

Twenty-five of these twigs were also washed with distilled water, each placed in a boiling tube, plugged with cotton wool, and kept until August 20th.

Five then showed the conidial stage of "canker," and two others had developed perithecia, the asci in one being mature, the asci in the other immature.

This evidence points to the "canker" fungus as being the cause of the wilting of these trusses, but no explanation is advanced as to the mode of infection.

IV. Notes on Pear Canker.

An "eye rot" of pears similar to the "eye rot" of apples was observed in an orchard at Wisbech: and during March, 1925, a shrivelled pear with a few scattered perithecia was found still adhering to the tree in an orchard in that area.

While visiting a large commercial plantation near Cambridge in April, 1926, an unusual form of pear canker was observed. The fruit trusses were found to be wilting and many were discoloured, the fruit stalks being black at the base. Leaves attached to these trusses were also discoloured, being black or blackish brown; diseased areas were noted at the base and middle of the petioles. Spores similar to the *Fusarium* stage of *Nectria galligena* were obtained from some of the leaf and fruit stalks. Lesions were observed on the young shoots of the previous year's growth, and these bore pustules typical of *Nectria galligena*. Pitmaston Duchess trusses were also found similarly affected at Bluntisham in Hunts. R. V. Harris* has described a somewhat similar form of canker on a trained pear tree (var. Beurré Diel) in a private garden at West Malling, but no mention was made of withering of fruit trusses, leaf symptoms only being described.

Mode of Infection. Wiltshire† has described infection through leaf scars and scab lesions; and Harris* infection of the current year's shoots through the bases of leaves still upon the tree. In this latter case it was not ascertained whether previous infection by the scab fungus was necessary for the canker fungus to gain an entrance. It is of interest therefore to state that these leaves similarly attacked, showed no scab fungus, nor had it at that date been observed on either pear or apple.

A further investigation is being made, to ascertain if the infection is stigmatic.

* Harris, R. V. An Unusual form of Pear Canker. Ann. Rep. East Malling Res. Stat. 1924.

† Wiltshire, S. P. Studies on the Apple Canker Fungus. I. Leaf Scar Infections. Ann. App. Biol. VIII. II. Canker Infections of Apple Trees through Scab Wounds. Ibid. IX.

SUMMARY.

1. One method of over-wintering of the apple "canker" fungus (*Nectria galligena* Bres.) is by the formation of perithecia upon shrivelled fruits.

2. The *Fusarium* stage of "canker" (*Fusarium Willkommii* Lindau) is responsible for an "eye rot" of Worcester Pearmain.

3. Evidence is brought forward to show that one case of wilting of Worcester Pearmain blossom trusses was due to the canker fungus, but no explanation is advanced as to the mode of infection.

4. An unusual form of pear canker is described.

In conclusion, I wish to thank Miss E. M. Wakefield, and Mr F. T. Brooks, for confirming the identification of the conidial stage of *Nectria galligena* Bres. upon the "eye rot" apples, and Messrs F. T. Brooks and F. R. Petherbridge for helpful criticism.

EXPLANATION OF PLATES I–III.

PLATE I.

Fig. 1. Shrivelled Worcester Pearmain apple surface covered with perithecia of *Nectria galligena*. ×4½.

Fig. 2. Four Worcester Pearmain apples showing typical "eye rot." Nat. size.

PLATE II.

Twig of Worcester Pearmain showing apple with "eye rot." Nat. size.

PLATE III.

Fig. 1. "Eye rot" obtained from Wisbech orchard. Reduced ½.

Fig. 2. "Eye rot" produced in healthy apples (var. Worcester Pearmain). By inoculation of conidial spores of "canker." Reduced ½.

THE DEVELOPMENT OF GEASTER VELUTINUS.

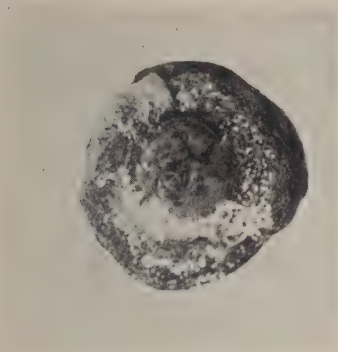
By G. H. Cunningham,

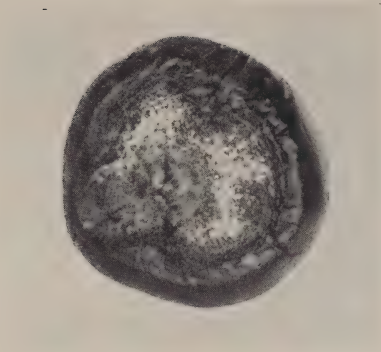
Government Mycologist, Biological Laboratory, Wellington, N.Z.

(With 9 Text-figs.)

So far as I am aware no study of the development of any species of the genus *Geaster*, nor of the related genera *Astraeus* and *Myriostoma* has been undertaken previously.

With a view to working out its development the writer searched for and obtained some twelve developmental stages of the epigaean species *Geaster velutinus* Morg., one of the commonest species of the genus present in New Zealand. These young plants were growing in the vicinity of numerous mature plants in a locality in the forest where the species has, to the writer's knowledge, been present for the past six years. It produces a superficial mycelial subiculum—quite noticeable in some cases, scarcely discernible in others—and upon this the young plants were found.





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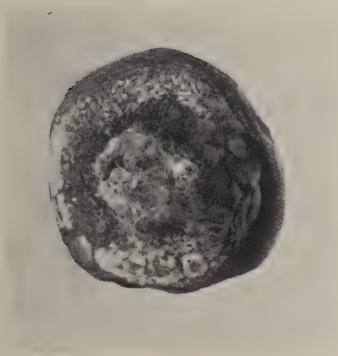

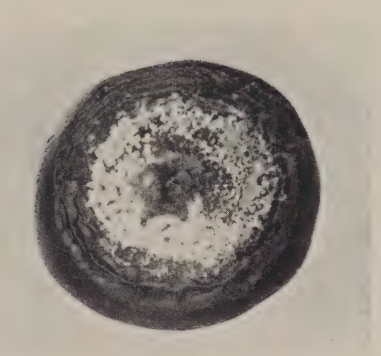

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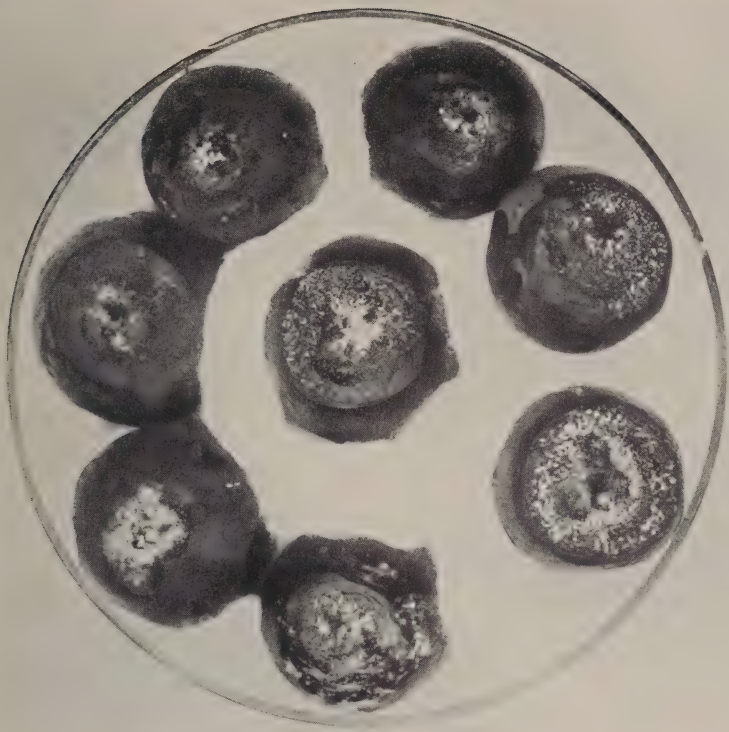

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Specimens were fixed in picro-formol, embedded and sections 5 μ and 10 μ were cut with a rotary microtome. These were stained with iron-alum haematoxylin and light green, and mounted in canada balsam.

Structure of the Mature Plant.

A typical specimen immediately before expansion is globose or ovate, superficial, 2–3 cm. diam., and attached at the base to the mycelial subiculum by a strongly developed mycelial cord. If sectioned the plant is seen to consist of several exterior layers enclosing a central sac. The outer layers subsequently split from the apex downwards into several stellate rays which remain expanded and appressed to the substratum or else become revolute, lifting the plant clear from it. The expanded

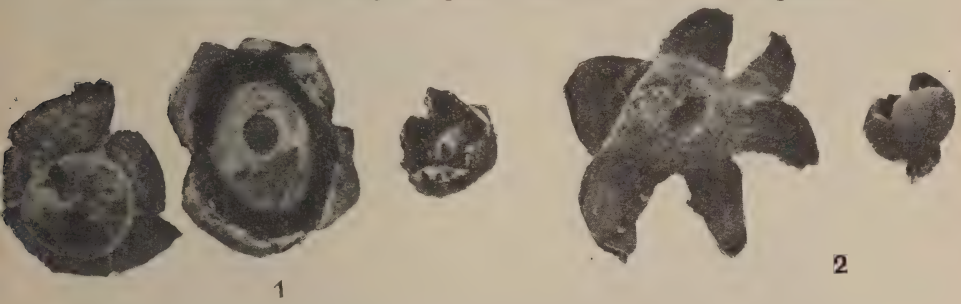


Fig. 1. *Geaster velutinus* Morg. × $\frac{2}{3}$. Saccate specimen in the centre, revolute specimen on the left, expanding plant on the right.
Fig. 2. Exterior of the exoperidium showing the tomentose exterior (more noticeable on developing plant on the right) and prominent umbilical scar—the point of attachment. × $\frac{2}{3}$.

plant now has a stellate but somewhat saccate appearance (Fig. 1), and bears in the centre a spore sac which is thin, membranous and perforated apically by a single opening, outlined by a more or less silky or fibrillose zone.

Thus the expanded plant is seen to consist of two well-defined groups of tissues, the stellate part being the exoperidium, the spore sac the endoperidium.

Exoperidium.

The exoperidium consists of three well-defined tissues:
(1) the mycelial or outer layer;
(2) the fibrillose or middle layer; and
(3) the fleshy or inner layer.

(1) *Mycelial layer*. This, the exterior layer, is well seen in unexpanded plants, being in the nature of a dense palisade, 1–2 mm. or more thick, of stout, deeply coloured, persistent hyphae. This layer persists throughout the lifetime of the plant,

and is, in fact, the principal character by which the species is distinguished from several related epigaean species.

(2) *Fibrillose layer.* This consists of intricately woven hyphae of two kinds, arranged with their long axes predominantly radial. The inner portion, next to the fleshy layer, is strengthened by numerous thick-walled hyphae similar to those of the capillitium. The whole tissue is tough and cartilaginous.

(3) *Fleshy layer.* This is pseudoparenchymatous. In freshly expanded plants it is soft, thick and flesh-coloured; after exposure it shrinks considerably, changes to some shade of brown, and often becomes rimose.

Endoperidium.

This structure encloses the gleba, consisting of capillitium and spores, and is attached by a broad base to and partially enclosed by the saccate portion of the exoperidium (Fig. 1). In texture it is membranous, and consists of numerous interwoven, partially gelatinised hyphae.

At the apex is a solitary stoma through which the spores escape. In this species the stoma is surrounded by a zone of parallel fibrils arranged radially, forming a broad, depressed zone.

The spores are globose, dark fuscous brown, strongly verrucose and reticulate, and very small, being 4–4·5 μ diameter.

The capillitium consists of innumerable fusiform, deeply-coloured, simple, continuous hyphae.

Outline of Development.

Development proceeds in the following order:

(1) Differentiation of the mycelial layer of the exoperidium.

(2) Simultaneous differentiation of the fleshy and fibrillose layers, gleba and columella.

(3) Lacunae appear in the gleba, and become lined with a palisade of primary basidia.

(4) Extension of development of lacunae with accompanying palisade of basidia, together with the formation of tramal plates, and later with the appearance of secondary basidia. This is the stage of intense spore production.

(5) The endoperidium becomes differentiated.

(6) Glebal formation (excluding the formation of the capillitium) is concluded.

(7) Peristome and stoma are formed.

(8) Tramal plates of the gleba become broken down and fragmented, and the capillitium grows out from the columella and endoperidium.

(9) The exoperidium becomes revolute and exposes the endoperidium.

Plants are first noticeable when about 2 mm. diam. At this stage they are composed of hyphae of two kinds, macro-hyphae 5–7 μ diam., and micro-hyphae 2–3 μ diam. Both are septate, much branched and intricately interwoven. Tissue differentiation begins shortly after plants attain to this size.

Fig. 3. Plant showing commencement of differentiation of the gleba and mycelial layer. ×15.

Fig. 4. Later stage showing (*a*) mycelial layer, (*b*) fibrillose layer, (*c*) fleshy layer, (*d*) primordium of the endoperidium, (*e*) glebal mass with lacunae. Section not median. ×10.

Fig. 5. Plant at a later stage; lettering as in the preceding figure, (*f*) columella. Section not quite median. Perforation in the upper portion of the gleba due to insect larva. ×7.

Fig. 6. Median section through plant shortly before collapse of the tramal plates; lettering as above, (*g*) disc of forming peristome. Note that fleshy layer merges abruptly into columella. Wrinkles in fleshy layer formed while section was being affixed to the slide. ×3.

Fig. 7. Photomicrograph of portion of the fleshy layer with the contiguous endoperidium. ×200.

Differentiation of the mycelial layer. In this species a true mycelial layer (as applied to hypogaean species) is wanting, modified hyphae taking its place, forming a tissue which is the first to be differentiated. When plants are approximately 3 mm. diam., numerous dark-walled, unbranched, simple hyphae arise at the periphery directly from the macro-hyphae. They grow radiately from the periphery of the embryonic plant, giving to it a tomentose appearance. As growth proceeds they become elongated, much convoluted, thick-walled, and form a dense layer 1–2 mm. thick, over the exterior (Fig. 4, *a*).

Differentiation of the fibrillose layer. This is first noticeable as a zone of unaltered tissue lying between the mycelial and fleshy layers (Fig. 4, *b*), differentiation beginning about the time the fleshy layer becomes definitely pseudoparenchymatous. At first it consists of both macro- and micro-hyphae, but soon the latter predominate, and become arranged with their long axes radial. Then a third type of hypha makes its appearance, being of the same nature as those forming the mycelial layer, here assuming a position parallel with the latter and serving to strengthen the whole tissue.

The fibrillose layer is of the same nature as primordial tissue (save that micro-hyphae predominate), the fleshy and mycelial layers arising from it as groups of specialised tissues.

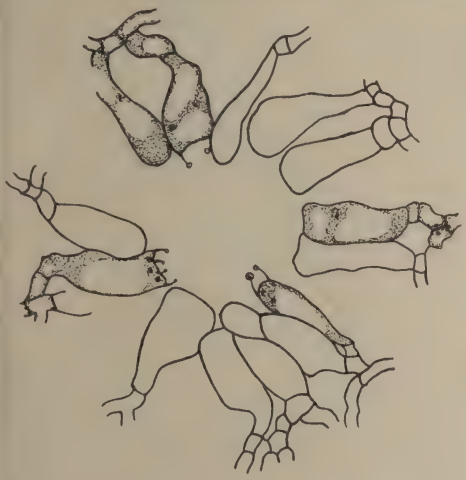
Differentiation of the fleshy layer. Shortly after differentiation of the mycelial layer, the fleshy layer originates as a zone of more closely interwoven and compacted hyphae lying between it and the central region of the plant (primordium of the gleba). This tissue consists almost entirely of macro-hyphae. Soon the hyphal walls become partly gelatinised and the whole becomes pseudoparenchymatous, and is then sharply delimited from the tissues which it encloses and those lying to the exterior (Fig. 4, *c*). It does not form a continuous zone, being interrupted by the thickened base of the columella, into which it abruptly merges (Fig. 6, *c*).

Endoperidium.

This comprises all tissues lying within the fleshy layer, and consists of the spore sac with its contents. In systematic papers it is usual to confine the term endoperidium to the spore sac alone, the capillitium and spores collectively being termed the gleba. This practice will be followed herein.

Gleba. At first this consists of undifferentiated primordium (Fig. 3), but shortly after differentiation of the fleshy layer begins, a dome of lacunae appears between the fleshy layer and the centre of the glebal mass (Fig. 4, *e*), and partially surrounding a non-lacunate region—the columella. The lacunae

arise as simple cavities in the glebal tissue. They vary in size and shape and appear to be formed by the tearing apart of the hyphae. They soon become lined with inflated cells of a size much greater than those of the surrounding hyphae. These inflated cells are in reality basidia, but as they differ greatly from those produced at a later stage they will be termed primary



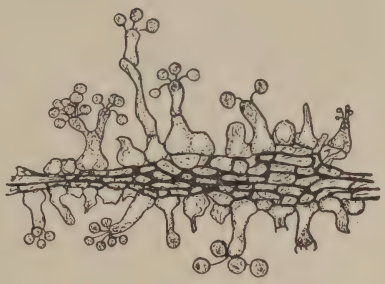


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Fig. 8. Primary basidia. Camera lucida drawing showing the arrangement of basidia around a lacuna in a section 5μ thick. Monosporous basidium in lower figure. × 500.

Fig. 9. Secondary basidia. Camera lucida drawing of portion of a tramal plate showing the gelatinised tissue of the plate (in black), basidia, sterigmata and spores. × 800.

basidia (Fig. 8). Owing to enlargement they compress the intervening tissues (between lacunae) thus giving rise to plates of tissue termed tramal plates (Fig. 6).

The primary basidia are irregular in size and shape and form a close palisade or hymenium lining the lacunae. They arise directly from modified portions of the hyphae of the tramal plates, a sub-hymenium, characteristic of most members of the

Agaricales, being absent. Many become monosporous shortly after their formation (Fig. 8), a condition not uncommon in certain other Gasteromycetes at an early stage in their development. Soon, however, the primary basidia become more regular in shape and bear several spores (usually four at this stage) on short sterigmata.

Next follows a period of rapid formation of lacunae and production of basidia, until the whole of the tissue enclosed within the fleshy layer (or rather the endoperidium, which appears shortly before this active period begins), save the columella, becomes converted into partly gelatinised tramal plates and basidia (Fig. 6).

Basidial development continues rapidly. Each basidium as it matures produces four to eight spores; these become detached, and the basidium collapses, to be replaced by another arising from a hypha of the tramal plate. Owing to this rapid development of basidia the plates become thinner and more lamellar, a change accompanied by a decrease in the size of the basidia. Decrease in size is rapid, so that shortly after spore production has begun the basidia are seen to be less than one-fourth the dimensions of the primary basidia. The smaller ones, which are responsible for the greatest spore production, are here termed secondary basidia (Fig. 9). They are usually four-spored, but eight-spored forms are not uncommon.

This period of intense spore production continues until finally little remains of the tramal plates but strands of partially gelatinised hyphae, with a few adhering, partially collapsed secondary basidia. Then the plates become fragmented and disappear, and at the same time the capillitium threads—hyphae of the same type as those comprising the mycelial layer—make their appearance. These arise principally from the columella; and in lesser numbers from the inner surface of the endoperidium. In consequence the columella becomes smaller as development of the capillitium threads continues, until in the mature plant often scarcely more than a rudiment remains.

The capillitium threads are long, unbranched (save occasionally at the apices), dark in colour, thick walled and acuminately pointed. Thus at maturity the tramal plates have disappeared, the whole of the interior being occupied by the capillitium and spores.

Spore production begins when the plants are 7–8 mm. in diameter, and continues uninterruptedly until the tramal plates break up.

The endoperidium consists of micro-hyphae identical with those of the fibrillose layer. The hyphae become closely and intricately interwoven and partly gelatinised; at first they are

attached both to the tramal plates on the interior and to the fleshy layer on the exterior, but shortly after the endoperidium is clearly defined, partial separation is affected by the tearing apart of the hyphae from the fleshy layer (Fig. 7). When the exoperidium becomes revolute, separation occurs along the junction of the fleshy layer and endoperidium, particles of hyphae persisting for some time as a pruinose covering on both the interior of the one and the exterior of the other.

Peristome. Shortly after the endoperidium has been formed, formation of the peristome begins. The hyphae at the apex of the endoperidium become more loosely interwoven and form a thickened apical disc (Fig. 6, *g*). The hyphae of the disc then assume a radial arrangement, a small irregular cavity appears in the centre and becomes lined with hyphae from the inner portion of the endoperidium. Then the disc collapses, becomes depressed and gives rise to the peristome, which now appears as a circular depressed region perforated by a circular orifice—the stoma (Fig. 1).

Finally rupture of the exoperidium occurs, and the endoperidium is exposed.

Cytology.

The cytology of this species is apparently simple. The hyphae are uninucleate and the nuclei exceedingly small, ranging in size from 0·5 to 1·0 μ in diameter. They are usually found in the vicinity of the septa. The basidia—both primary and secondary—also are uninucleate, the nuclei being about the same size as those of the hyphae. Owing to the exceedingly small size of the nuclei, no chromosomes have been observed.

The behaviour of the nucleus within the basidium during spore production is apparently similar to that of certain other uninucleate Basidiomycetes, the plant appearing to be haploid throughout. The fusion nucleus present in the basidia of *Secotium* and certain species of the Agaricales prior to spore production has not been observed, for at all stages of its development prior to spore production the basidium is uninucleate.

Shortly after the basidium is formed sterigmata grow from the apex. When these are about 3 μ long terminal inflations appear—the developing spores. Until this period the nucleus remains unchanged, but with the beginning of spore formation it rapidly changes, and divides until the number of nuclei are equal to the number of spores produced. Such division may occur in any part of the basidium, but as the sterigmata are developing the nucleus usually takes up a position near the apex of the basidium and there divides. Four is the usual number of spores produced, consequently it is usual to find

this number of nuclei formed by successive divisions of the nucleus. Actual migration has not been observed, owing, no doubt, to the exceeding fineness of the sterigmata (0·25 μ or less) but spores of a diameter of less than 2 μ are seen to possess no nuclei whereas others larger than this are invariably and constantly uninucleate.

At an early stage of development the epispore is quite smooth, but shortly after migration of the nucleus it becomes minutely roughened, and as the spores enlarge the degree of roughness increases until at maturity they are seen to be closely covered with fine, flat-topped verrucae. Immediately after its detachment from the basidium the spore is seen to be shortly pedicellate—due to the persistence of a portion of the sterigma, but this structure apparently disappears, for in spores from a mature plant it is not noticeable.

As all attempts to germinate spores have failed, it has not been possible to observe nuclear behaviour during germination, nor to ascertain whether the first hyphae produced are uninucleate. This peculiarity of non-germination under all laboratory conditions is apparently common in the Lycoperdaceae, for the writer has failed in all attempts to germinate spores of *Bovista*, *Bovistella*, *Calvatia*, *Disciseda*, *Geaster* and *Lycoperdon*. No clamp connections have been observed, either in the vegetative mycelium or in the mycelium of the tissues of the fructification.

All photographs by H. Drake; drawings and photomicrograph by the writer.

NOTES ON NECTRIA RUBI.

I.

By G. H. Pethybridge,

Pathological Laboratory, Ministry of Agriculture and Fisheries, Harpenden.

THE diseases of raspberries have not hitherto been the subject of extended investigations in this country. In recent years, however, their importance has become increasingly recognised both by growers and by plant pathologists, and these diseases are now being studied in detail at the East Malling Fruit Research Station* and elsewhere.

* An interesting account of the Verticillium Wilt of Raspberry has already been published by Mr R. V. Harris of this Station (see Journ. Pomology and Hort. Sci. IV (1925), p. 221), and Messrs N. H. Grubb and A. M. Massee have published a short note on Raspberry Mosaic (see Ann. Rept. E. Malling Research Station for 1923, p. 131). *Plectodiscella veneta* Burk., the cause of Raspberry Anthracnose in America, has also recently been identified on English material at E. Malling.

For this reason, and because a number of enquiries have been received on the matter, it seems desirable to put on record a note of some work done a few years ago in Ireland by Mr H. A. Lafferty and myself in connection with a fungus which we regarded as identical with *Nectria Rubi* Osterw.

In the summer of 1916 some dead and dying raspberry plants were received from Sir F. W. Moore, Keeper of the Royal Botanic Gardens, Glasnevin, Dublin. Some of the material came from Co. Dublin and some from Co. Down. On the canes there were certain bleached areas on which perithecia of *Didymella applanata* Sacc. were present, but it was clear that this was not the real cause of the generally unhealthy condition of the plants. After carefully washing away the soil which adhered to the stools, numerous perithecia of what appeared to be a species of *Nectria* were discovered on the crown, close to the points of origin of the canes. Similar perithecia were also found on the bases of canes which had previously been cut back, as well as on the bases of the dead and dying canes still present. The roots were dying or dead, but no perithecia were found on them.

The young perithecia were of a bright red colour, the older ones somewhat darker, while the oldest were almost black. They were more or less spherical, but possessed a short papilla-like neck with an ostiole. Their transverse diameter varied from 300 to 500 μ and the average of several measurements was 450 μ. They were smooth and seated in groups on a stroma which broke out through the bark. In each perithecium there were numerous asci, averaging 120 μ long and 6 μ broad, each containing eight two-celled ascospores arranged in a single row. These spores were slightly constricted in the middle, the two cells being sometimes equal in size, sometimes unequal. They were hyaline, or of a faintly smoky colour, and measured on the average $12{\cdot}8 \times 5{\cdot}5\ \mu$. When quite ripe their walls were sometimes faintly spinulose. Paraphyses were present and were elongated, thin and whip-like. In ripe perithecia they were seen with difficulty or not at all. When the material was kept for a day or so in a covered moist dish the ascospores were extruded, and lay as a white mass around the ostiole.

When the decaying roots were kept moist, patches of greyish white aerial mycelium developed on them in a couple of days, which microscopical examination showed to belong to a *Fusarium*. The conidia present were 0–5-septate, sickle-shaped, and possessed a distinct "heel"* at the base, where the wall

* For the mode of origin of this "heel" in *Fusarium* conidia see Sci. Proc. Roy. Dublin Soc. xv (N.S.), (1917), 204. The same thing occurs in *Hypomyces Solani*; see Trans. Brit. Myc. Soc. vi (1919), 113. In cultures in which conidia are produced rapidly the "heel" is frequently absent, and it is therefore of little use for diagnostic purposes.

was thinner. They averaged $12 \times 5{\cdot}3\,\mu$ when non-septate and $60 \times 7\,\mu$ when 5-septate; those having from one to four septa were of intermediate sizes between these two extremes. The conidiophores on which they were borne were considerably branched.

On account of the general appearance of the fungus and of its behaviour when grown subsequently in pure culture and in spite of certain slight variations in spore measurements, it was considered to be identical with *Nectria Rubi* described by Osterwalder* in 1911, and was recorded under this name†.

Osterwalder found violet-coloured sporodochia of a *Fusarium* on the roots of diseased raspberry plants. A few days after the material had been placed in a moist dish, perithecia—at first yellowish green and then red—began to develop on the sporodochia, which, from their location, he surmised were connected with the *Fusarium*. Pure cultures were raised, starting from a single ascospore and a single conidium respectively, and from their behaviour it was concluded that the *Fusarium* was a stage in the life history of the *Nectria*. Although the *Fusarium* stage was obtained in cultures emanating from an ascospore, no perithecia developed in any of the cultures. The violet coloration appeared in some instances but not in others, its production being dependent, apparently, on the nature of the substratum used.

A fairly extensive series of parallel cultures on various media was carried through by Mr Lafferty working with the Irish material. The starting-point of each series was a single *Nectria* ascospore and a single *Fusarium* conidium respectively. The cultures behaved similarly in every respect and showed that they appertained to one and the same fungus. The *Fusarium* stage developed rapidly in each series, and after the lapse of nearly six months perithecia also developed in cultures derived from both sources. These perithecia were at first whitish, then yellow and finally red. The asci in them were, on the average, slightly shorter than those in the perithecia on the original raspberry material, but the ascospores were approximately of the same size. In this way, therefore, the connection between the *Nectria* and the *Fusarium* stages was proved by growth in pure culture.

The fungus caused the liquefaction of wort gelatine, and the liquid took on a deep claret colour. Claret-coloured granules were also present in the cells of the submerged hyphae. The same colour was developed on oat-extract agar and Quaker Oat agar. Osterwalder found that his fungus caused the liquefaction

* Osterwalder, A. Ueber eine neue auf kranken Himbeerwurzeln vorkommende Nectria und die dazu gehörige Fusarium-Generation. Ber. d. Deut. Bot. Gesell. XXIX (1911), pp. 611–622.

† Royal Dublin Society, Report of the Council for the year 1916, p. 63.

of raspberry-root-decoction gelatine, and in cultures derived from an ascospore a violet coloration appeared. The same coloration appeared in cultures of similar origin on sterilised potato stalks.

The question of the parasitism of *Nectria Rubi* still remains to be settled. Osterwalder carried out but few infection trials, and only with the *Fusarium* conidia. His results were negative, but he surmised that he might have been more successful had ascospores been used as the inoculum. With the Irish material six healthy raspberry plants of three different varieties growing in pots were inoculated in June, 1917, by the present writer, through wounds in the woody stock below ground level, with material taken from a pure culture on Quaker Oat agar derived from a single ascospore; and five plants of the same varieties, wounded but not inoculated, served as controls. The results, however, were purely negative, and, owing to various difficulties, the work had to be discontinued.

The same fungus now appears to have been discovered on ailing raspberry plants both in Scotland* and in England. It is to be hoped that further research will now be possible and that the question as to whether this fungus really causes a disease of raspberries may be satisfactorily cleared up.

II.

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In view of the finding of *Nectria Rubi* in Ireland and in Scotland, it seems desirable to add a brief note on its occurrence in England.

During the last two years the writer has observed numerous cases of a disease of raspberry canes in the west of England which might well be described as "Crown Rot." The diseased plants appear to make normal cane growth during summer and autumn, but this is followed in spring by the failure or partial failure of the bud-break. Leaves may open normally, but wilting quickly takes place and is followed by die-back of the cane. Examination of affected plants shows that the whole or part of the internal tissue in the region of the crown and main root is discoloured and invaded by fungal hyphae. At a sufficiently early stage, a narrow strip on one side of the root and crown frequently remains healthy; and from this a normal sucker may arise. This sucker remains healthy and makes

* Alcock, N. L. A Note on Raspberry Canker (*Nectria Rubi* Osterwalder). Trans. and Proc. Bot. Soc. Edinburgh, XXIX (1925), 197.

normal growth while assimilation is active, but becomes invaded at its base by hyphae when growth ceases, thus bringing about in the following spring the symptoms described, when the diseased tissue extends further up into the affected canes. It is observed that the "plug" which is formed at the base of the preceding year's cane in healthy plants, and which normally prevents the entrance of fungi, fails to form in the diseased canes, so that any fungi inhabiting the old canes continue to grow down into the crown.

In May, 1925, specimens of Baumforth's Seedling, showing the general symptoms described above, were received from Worcestershire. In the region of the crown and upper portion of the main root numerous immature bright red perithecia were scattered singly or occurred in groups on the surface of the bark. The contents of the perithecia consisted of thread-like paraphyses and asci, each of the latter containing eight two-celled ascospores. When mature the perithecia turned almost black, and in a moist atmosphere white tendrils of ascospores were extruded through the ostiole. Such perithecia were spherical, with a slightly papillate ostiole, and measured 420–560 μ in transverse diameter. The asci were club-shaped and hyaline and measured 85–100 $\mu \times$ 6–8 μ. The two-celled ascospores were hyaline or faintly coloured, and constricted at the septum. Each cell was slightly pointed and contained one oil drop. The spores measured 11·2–14·7 $\mu \times$ 5·5–7 μ. The ascospores were slightly smaller than those described by Osterwalder for *Nectria Rubi* (15·9–18·6 $\mu \times$ 4·6–5·2 μ) but the measurements agreed closely with those given by Pethybridge above and by Alcock*. Prior to germination there is a slight enlargement of one or both cells of the ascospore, and it is possible that this may account for the slightly larger size found by Osterwalder.

Plates were poured of a suspension of the ascospores in malt extract agar. The resulting individuals were at first white, but in about ten days they took on a deep violet colour and were found to be bearing conidia of the *Fusarium* type. Typical conidia were hyaline, 3–4-septate, curved, with rounded extremities and measured 45–59 $\mu \times$ 6–8 μ.

Though sporodochia of the *Fusarium* stage of *Nectria Rubi* were observed by Osterwalder, and by Pethybridge and Lafferty on the roots of diseased raspberry plants, they have not so far been observed on specimens found in England. Isolations from the inner tissues of roots, however, have yielded violet-coloured mycelium which produces conidia identical with those formed in the cultures derived from ascospores.

Pure cultures derived from ascospores and *Fusarium* conidia

* Loc. cit.

have been studied comparatively on various media. Whatever the origin of the culture, on the same medium, no appreciable difference was observed. In culture, the fungus forms a tuft-like mass with a well-marked strigose margin. This marginal portion is made up of radially arranged fasciculate masses of mycelium, which break up at their tips into individual diverging hyphae. This form of growth is more marked on woody media such as apple wood and raspberry root than on agar and potato media.

On malt extract agar growth is compact and cushion-like with strigose margin. The deep violet colour appears within about ten days and is associated with the formation of conidia; the actively growing mycelium on the margin remains white. In older cultures marked zoning appears, with alternating rings of violet and brown, corresponding to abundant conidial formation and sterile hyphae respectively. The violet colour disappears when growth ceases and no further conidia are formed. No perithecia have been found in agar cultures.

On glycerine-potato slice growth is vigorous with exceptionally abundant conidial formation. The characteristic violet colour is apparent in the early stages; the aerial mycelium, however, soon turns a sepia brown colour. Zones of aerial hyphae 4–5 mm. wide alternate with zones consisting of a white, viscid mass of conidia. The whole of the surface of the cotton-wool plug supporting the slice becomes covered with a similar mass of conidia. After about five months perithecia were observed to be forming on the lower surface of the cotton-wool plug. They were at first white, later, red, eventually turning a dark reddish brown. A well-marked subiculum was present at the base of each perithecium.

On ordinary potato slice growth proceeded more slowly, a white, flocculent mycelium, with pale claret-coloured zones being produced.

On raspberry root and apple wood a deep violet colour is evident in some cases and is more persistent in cultures started from mycelium. On such substrata exceptionally vigorous formation of conidia takes place. On the aerial hyphae the conidia are borne on short much-branched hyphae arising at right angles to the main hyphae and give the mycelium a powdery appearance. In general the colour varies from mauve to chrome-orange. In all cases the violet colour is evanescent, turning later to chrome-orange. The conidia are produced later in viscid masses taking the form either of white, mauve or yellow globules or of a yellow viscid film on the surface of the substratum.

In both apple-wood and raspberry-root cultures, after about

eight weeks, large numbers of perithecia were observed to be forming on the aerial mycelium, 2–3 mm. from the surface of the substratum. They were borne on the tips of the whip-like hyphae which diverge from the fasciculate mycelium, and were at first transparent olive green, but later turned black.

Perithecia from these cultures and from the glycerine-potato culture are somewhat smaller than those occurring in nature and measure 350–490 μ in diameter. The ascospores themselves do not differ in size from those which occur in perithecia on the raspberry. In about twelve weeks the perithecia were mature and extruded their ascospores through the ostiole.

When ripe perithecia were placed in a drop of water ascospores were violently expelled from the ostiole in a series of small explosions, the empty asci being forcibly expelled later in the same way.

From single ascospores derived from the perithecia developed *in vitro*, cultures were made and grown in malt extract agar; the resulting individuals produced *Fusarium* conidia and were identical in every way with the original ascospore cultures, thus confirming the relationship between the two stages in the life history of the fungus described by Pethybridge above.

As will have been seen in the preceding note, there is no record of successful inoculations having been carried out with *Nectria Rubi*, nor is there yet any direct evidence to show that the fungus is definitely parasitic. The investigation of several cases of "Crown Rot" has failed to reveal any trace of *Nectria Rubi* except in isolated instances, *e.g.* from plants from Worcestershire and Long Ashton; on the other hand, *Diaporthe perniciosa* March. is almost always present. Further, "Crown Rot" has so far only been found by the writer to occur in areas that tend to lie wet in the winter. It is possible that prolonged waterlogging such as may occur in an abnormally wet season may set up physiological disturbances in the plant, preventing the normal "plug" formation, and so allowing the entry of fungi such as *Diaporthe perniciosa*. *Nectria Rubi* may act as a follower or may play a joint part in causing the death of the plant. In this connection it is perhaps significant that *Nectria Rubi* was discovered by Pethybridge in 1916 following the wet year of 1915, and it was first found in Scotland and England in 1925 following the wet year of 1924.

Reference may be made here to another fungus of the *Fusarium* type which has been found by the writer on diseased raspberry roots. The conidia of this fungus are borne on white sporodochia which burst through the bark below soil level. Typical conidia differ markedly from those of *Nectria Rubi*. They are smaller, very slightly curved, 3–4-septate and are

attenuated slightly towards one extremity. Average conidia measure $37 \times 5\,\mu$. In size and shape they agree with those of a species of *Fusarium* mentioned by Wormald* as occurring on diseased raspberry roots. This fungus has also been found in association with "Crown Rot"; but it is not considered to have any relation to *Nectria Rubi*, since it differs considerably, not only morphologically, but in cultural characteristics, from the conidial stage of that fungus. Further attention is being devoted to this *Fusarium*.

Addendum.

Since the above notes were written a paper has come to hand from Dr Wollenweber, "Pyrenomyceten-Studien, II" (*Angew. Bot.* VIII (1926), 168), in which some reference to *Nectria Rubi* is made. In *Phytopathology*, III (1913), 211 and 224, Fig. 15, Plate XXII, Wollenweber transferred this fungus to the genus *Hypomyces* because it produces chlamydospores, although not abundantly. It is also listed in that genus in this author's "*Fusaria* autographice delineata" (*Ann. Mycolog.* XV (1917), 8); but in his 1926 paper, mentioned above, it is reinstated in the genus *Nectria*; and *Nectria mammoidea* Phil. et Plow. var. *Rubi* Weese and *Cylindrocarpon janthothele* Wr. are given as synonyms. Although it would appear from the statement on p. 169 of the 1926 paper that Dr Wollenweber regards the fungus as a parasite (*Wurzelschädiger*) of raspberry, in a letter to the writer he admits that this has not yet been proved. Nevertheless, he points out that it belongs to a group of related fungi which are injurious to plants and probably forms no exception.

G. H. P.

THE PARASITISM OF PLOWRIGHTIA RIBESIA ON THE CURRANT†.

By Ismé A. Hoggan, M.Sc. (Cantab.), M.S. (Wisc.)

(With Plates IV–VII and 2 Text-figs.)

Introduction.

Plowrightia ribesia (Pers.) Sacc. has long been known as a fungus causing a disease of the currant, and its morphology has been worked out in detail by previous investigators. Little consideration, however, has been given to the pathological aspects of the disease, and the present paper deals with an in-

* Wormald, H. Journal of the South Eastern Agricultural College, No. 22 (1923), 481.

† This work was submitted as a thesis in partial fulfilment of the requirements for the degree of M.Sc. at Cambridge University in 1925.

vestigation carried out primarily from this point of view. The main purpose of the work was to determine the natural mode of infection of the host and the extent to which the fungus might be regarded as a parasite. An account of certain cultural and other studies is included. The work was undertaken on the suggestion of Mr F. T. Brooks, and was carried out under his supervision at the Cambridge Botany School.

Literature.

Tulasne (1) describes various spore forms on the currant which he ascribes to *Dothidea* (*Plowrightia*) *ribesia*. He mentions oval, hyaline conidia which are abstricted in great numbers from stout, closely crowded conidiophores arising from the black pustules of the fungus; small, rod-like spores arising from the walls of irregular cavities in the stroma; perithecia containing asci, and a pycnidial stage externally resembling the perithecial pustules, but producing numerous, small, hyaline conidia which later become dark-coloured and septate.

Brefeld (2) supplements Tulasne's account with a detailed description of the behaviour of the ascospores and conidia in culture. He states that the ascospores send out germ tubes usually from both ends; these abstrict numerous hyaline conidia. Similar conidia may form at the poles and at the septum of the spores before or after germination, while other ascospores germinate purely vegetatively, forming short, profusely branched hyphae which may become dark green in colour. The conidia multiply rapidly by a process of budding, and later proceed to the formation of gemmae. Brefeld doubts the identity of Tulasne's pycnidial forms with *Plowrightia ribesia*, but includes the conidial stage on the stroma on account of the characteristic budding of the spores.

Massee (3) is the first to consider the relation of the fungus to its host. He inoculated two healthy young plants, one gooseberry, one red currant, from material of the fungus obtained upon gooseberry, "by introducing spores into incisions made in the bark." After seven weeks the infected parts appeared dry and shrivelled, and within three months pustules of the fungus developed to a distance of one inch above and below the point of inoculation. Since no infection was obtained by placing spores on uninjured bark, he concludes that the fungus is a wound parasite. Later (4), he writes: "...in all probability aphids or scale enable the parasite to gain an entrance into the living tissues of the host." He states that wilting and yellowing of the foliage is the first indication of the disease, and that the branch is usually killed the second year after infection owing to the water-supply being cut off by the development of mycelium in the vessels. He

mentions gooseberry and red and black currant as hosts, and states that the fructifications do not appear until the branch is quite or nearly dead.

Field Observations.

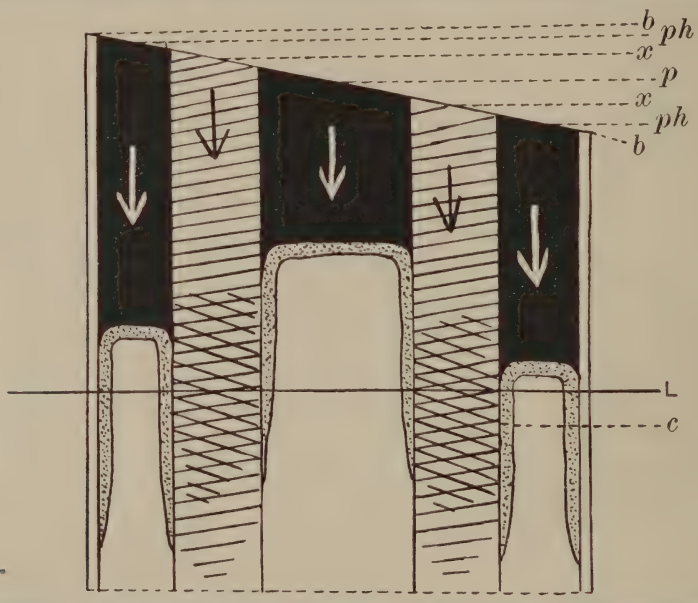
The disease was found to be of common occurrence on red currant, and less frequent on black currant. No infected gooseberry bushes were observed by the writer. The characteristic symptoms of the disease are isolated, dead branches bearing the black lenticular or oval stromata of the fungus (Plate IV, fig. 1). These stromata break through the bark in late summer and develop perithecia during the winter months. The spores are delimited in the asci about January and reach maturity about the following April.

Usually from one to several infected branches are found upon otherwise healthy bushes, while sometimes the main axis is attacked and the entire bush killed. Such bushes are generally relatively old or grown in neglected orchards. Some hundreds of bushes were examined in various orchards—chiefly red currant—and a very high percentage of these proved to be diseased. With three exceptions, which will be considered later, each diseased branch had previously been pruned back or was directly connected with a second infected branch which had been pruned. This suggested that the fungus might effect an entry through the cut surfaces left in pruning, but gave no indication whether infection could occur through unbroken surfaces. The diseased twigs were infected to distances of from one quarter of an inch upwards from the cut surface, the entire spur frequently being invaded. The infected portions were shrivelled and bore fructifications of the fungus; a sharp line of demarcation could be distinguished externally between the diseased and healthy regions of the stem. It was evident here that the fungus had entered at the cut surface and was working back towards the base of the spur.

Certain other fungi were commonly found associated with the *Plowrightia*, such as *Cladosporium* and *Alternaria*; by far the most frequent was the coral-spot fungus, *Nectria cinnabarina*, which was encountered so regularly at one period that it became exceptional to find material of *Plowrightia* free from this fungus. The red pustules were scattered among the black stromata of the *Plowrightia*, and frequently arose at either end of the stromata, contiguous with them, or pushing up immediately beneath them and even enclosed within them. It seemed possible that *Nectria* might prepare the way for subsequent infection by *Plowrightia* and one series of inoculations was carried out to test this possibility.

Pathological Histology.

The mycelium of the fungus presents a very characteristic appearance in the stems and is easily recognised (Plate V, fig. 2). The hyphae are extraordinarily stout when mature, as much as 20 μ or more in width, and grow in the cells in a very twisted and gnarled manner; they have numerous septa and are deep olive green or brown in colour. The young hyphae are hyaline, much narrower, and take up stains readily. The mycelium invades all tissues of the stem within the bark, being particularly

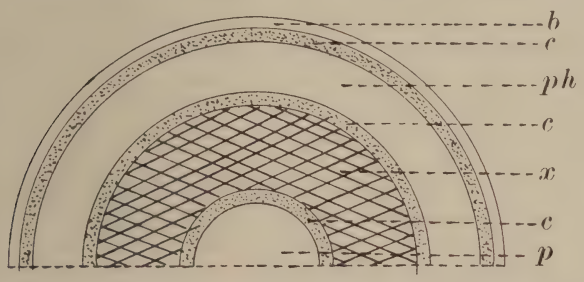


Text-fig. 1. Diagram illustrating formation of cork layers in diseased stem of red currant. Radial longitudinal section. *b*, bark; *c*, cork; *p*, pith; *ph*, phloem; *x*, xylem. Black areas represent diseased tissue, white areas healthy tissue and shaded areas regions of wood with resinous contents. Arrows indicate direction of progress of mycelium.

abundant in the phloem and pith, causing a dry rot of these tissues. Here the hyphae grow in a dense, tangled mass; in the wood they are less abundant and pass from one cell to another through the pits in the walls. They appear to travel in a vertical direction through the vessels and tracheids, and horizontally through the medullary rays (Plate V, figs. 2 and 3). The diseased pruned twigs which were infected part of the way down from the cut surface invariably showed the formation of certain layers of cork at the junction of the diseased and healthy tissues, corresponding in position to the line of demarca-

tion between the two regions previously mentioned. The position of these cork layers will be understood best from the above diagrams (Text-figs. 1 and 2).

One layer stretches completely across the pith in a horizontal direction to the wood, then curves sharply downwards and runs vertically downwards for a considerable distance immediately inside and adjacent to the protoxylem, or in some cases between the protoxylem and the metaxylem, thus forming a complete cylinder of cork enclosing the pith and closed at the top. This bars the passage of mycelium from the wood outside or from the diseased pith above, into the healthy pith inside the cork cylinder (Text-fig. 1). Similar formations occur in the phloem, consisting of a horizontal sheet of cork extending from the bark to the outer edge of the wood, and running vertically downwards between the bark and the outer edge of the phloem, and



Text-fig. 2. Transverse section of same at level *L*, Lettering as in 1.

between the inner edge of the phloem and the wood (Text-figs. 1 and 2). This blocks the way of the mycelium from above or from the side into the healthy phloem area within the cork layers. The wood at this level is much discoloured by masses of resinous substances secreted in the vessels and medullary rays. Since no hyphae could be detected in these discoloured regions it seemed as though the resinous substances also serve as a barrier to the advancing mycelium, so that further progress down the stem is prevented in all parts. In some twigs, however, two or three such series of cork layers may be found at different levels, the lowest separating the healthy and diseased tissues as before, the others situated within the diseased region of the stem, suggesting that in some way the mycelium had been able to evade the barrier of cork and resin and penetrate further into the host. This will be referred to again later.

Inoculation Experiments

The field observations above recorded led one to suspect that the pruning wounds served as a point of entry for the fungus,

but gave no indication whether normal healthy branches were also susceptible to infection. Experiments were therefore carried out to determine the susceptibility to infection of the following:

1. Healthy branches.
2. Artificially pruned branches.
3. Artificially killed branches.

Both mycelium and ascospores were used as sources of inoculum. Pure cultures of mycelium were obtained by the following method. Stromata were sterilised by immersion in a one per cent. solution of mercuric chloride for fifteen seconds, and washed in sterile distilled water. Sections were cut with a sterile razor and plated out on red currant wood-extract agar in Petri dishes. An abundant mycelium developed in a few days and was transferred to sterile portions of red currant stems where it grew luxuriantly. The ascospores were obtained by suspending sterile coverslips over mature moistened stromata in sterile Petri dishes, when the spores were shot upwards and collected on the coverslips. From these a spore suspension in water was made. Red and black currant bushes three or four years old were used for inoculation purposes, and were grown in large pots in the open.

(1) *Inoculation of healthy branches.* The inoculum was inserted into deep wounds made with a sterile knife into healthy, growing branches, and the wounds were immediately covered with tin foil and bound with wool. When mycelium was employed, a drop of sterile water was added with the inoculum. When ascospores were used, germination tests were carried out at the same time to prove that they were viable. The results are summarised in Table I.

Table I. *Inoculation of healthy branches of currant.*

Inoculum	Host	No. of inoculations	No. of infections
Mycelium	Red currant	34	0
Mycelium	Black currant	20	0
Ascospores	Red currant	16	(2)[1]
Ascospores	Black currant	16	0

[1] These two infections were obtained on branches which were not in a healthy condition at the time of inoculation.

With two exceptions, no infection resulted from these inoculations, the branches remaining healthy after six to twelve months. In the two exceptional cases where infection was obtained, branches had purposely been selected which appeared in a moribund condition with yellowing leaves, though showing no

further symptoms of disease and arising from apparently healthy branches. They cannot, however, be included in the category of normal healthy branches.

Microscopic examination of other inoculated twigs revealed a small patch of discoloured tissue surrounding the wound, consisting of dead phloem and pith cells and wood elements with resinous contents, these frequently being bounded by an irregular cork layer. A certain amount of mycelium was present in the discoloured region, and this was still living, as subsequent plating-out tests demonstrated, but was evidently unable to spread.

(2) *Inoculation of artificially pruned branches.* Healthy branches were cut back with a pruning knife and inoculum placed immediately on the cut surface and covered with tin foil, or the cut surfaces were covered at once and inoculated later after intervals varying from one to nine weeks after pruning. The results are given in Table II.

Table II. *Inoculation of artificially pruned branches of currant.*

Inoculum	Host	Interval between pruning and inoculation	No. of inoculations	No. of infections
Mycelium	Red currant	0	10	0
,,	Black currant	0	10	0
Ascospores	Red currant	0	16	14
,,	Black currant	0	8	6
,,	Red currant	1 week	8	5
,,	,,	2 weeks	8	7
,,	,,	3 ,,	8	8
,,	,,	4 ,,	8	6
,,	,,	6 ,,	8	6
,,	,,	9 ,,	8	6
,,	Black currant	9 ,,	8	5

Inoculation with mycelium gave negative results, but with an ascospore suspension, of a total of eighty inoculations, sixty-three gave positive results, the twigs becoming infected to distances of half an inch and upwards from the cut surfaces and developing fructifications three to five months after inoculation. The diseased twigs closely resembled the naturally infected pruned twigs previously described, showing a shrivelled diseased portion and a sharp line of demarcation between the healthy and diseased tissues, where a similar development of cork layers had occurred. No further spread of mycelium took place beyond this point during the winter months, the inoculations having been performed in May and early June. The following summer, in a single twig, the mycelium worked past the cork zone and invaded the entire branch, fructifications developing on the newly infected area. No further spread of mycelium occurred, however, on any of the other inoculated spurs.

In order to follow more closely the progress of infection by the ascospores, a number of healthy branches were removed from red currant bushes, the tops cut back, and the cut surfaces inoculated immediately with a spore suspension. The twigs were kept in the laboratory under moist conditions and hand sections were examined microscopically at twenty-four hour intervals for a week. Twenty-four hours after inoculation, a number of ascospores had begun to germinate. These lay on the surface of the cut, or in the wood vessels at a short distance below the surface. Others had abstricted numerous bud spores, a few of which later produced germ tubes which penetrated the tissues of the stem. After three days an abundant mycelium had developed from the ascospores, the hyphae invading the vessels, the pith and the phloem to a depth of about two millimetres, growing at first more rapidly in the wood elements but after a week or more becoming more abundant and progressing slightly more rapidly in the phloem and pith. The mycelium then spread rapidly throughout the stem, and if these were kept sufficiently moist, fructifications developed on the surface within two months. In the early stages of infection the mycelium was strictly intercellular in the pith and phloem, only entering the cells after they were killed; in the wood the mycelium was intracellular.

(3) *Inoculation of artificially killed branches.* Healthy branches were killed by subjecting the base to a steam jet for several minutes, and after a few weeks, when the leaves had shrivelled, wound inoculations were made one or more inches above the steamed region. Inoculations were also made with mycelium of *Nectria cinnabarina* alone and in combination with mycelium of *Plowrightia* to determine whether the former bore any relation to infection by *Plowrightia*. The results are summarised in Table III.

Table III. *Wound inoculation of artificially killed branches of red currant.*

Inoculum	No. of inoculations	No. of infections
Ascospores of *Plowrightia*	12	10
Mycelium of *Plowrightia*	24*	18
Mycelium of *Plowrightia* and of *Nectria*	4*	3 (*Nectria*) 0 (*Plowrightia*)
Mycelium of *Nectria*	4*	3
Mycelium of *Plowrightia* followed 3 months later by mycelium of *Nectria*	4*	3 (*Nectria*) 0 (*Plowrightia*)

* One inoculation made at a distance of one inch from the steamed area, this giving negative results.

Infection was obtained from both mycelium and ascospores of *Plowrightia*, fructifications developing within three months

above and below the wound. When, however, *Plowrightia* was inoculated together with, or subsequent to infection with *Nectria*, it failed to develop. Where an inoculation was made at a distance of one inch from the steamed area, infection in no case resulted, no matter what the inoculum.

Discussion.

The inoculation experiments recorded above indicate that *Plowrightia ribesia* is unable to infect normal healthy branches of the currant, even when these are wounded, but that infection by ascospores readily takes place through spurs left in pruning. That this is a common mode of infection in nature is indicated by the field observations previously described. The experiments further demonstrate that the fungus readily invades moribund tissue, and it appears probable that it must in every case establish itself first upon such tissue before being capable of attacking the living portions of the host. When a twig is pruned, the upward flow of sap is checked, and the remaining spur will gradually die back from the tip. Hence dead or dying tissue is formed which is freely exposed to the ascospores of the fungus and in which it can gain a footing. It has been shown that, once established, the mycelium can work backwards into the stems, gradually invading the living tissues until the way is barred by the cork and resinous layers which later develop in the stem. In this way *Plowrightia* behaves as a weak "wound parasite," in a manner very similar to *Nectria cinnabarina* upon the currant, as described by Line (5). It has further been shown that the mycelium is able in some way to evade the cork barrier and resume its progress down the stem. It is unlikely that the hyphae could pass through the cork layer itself, and the only alternative way is through the xylem elements in which resinous materials have developed. Hiley (6) discusses a similar situation with regard to *Dasyscypha calycina* on the larch, and concludes that the mycelium either slips through between the cork and the wood, or through the wood itself, though he did not observe any mycelium in either of these positions. In the isolated instance recorded above of inoculation of artificially pruned branches where the mycelium penetrated beyond the cork barrier, microscopic examination subsequently revealed the presence of a few hyphae of the fungus running down through the vessels in the discoloured region of the wood. It is therefore concluded that the mycelium can and does grow down through this area of the wood and so works downwards towards the base of the branch. The cork layers develop in late summer when the growth of the fungus is presumably slowing up or has

already ceased. The next spring would bring a renewal of activity on the part of the fungus which might enable it to penetrate the barrier.

The ascospores are liberated from the perithecia under natural conditions from the end of April to the middle or end of June. It appears to be a common practice in England to prune the currant bushes at the end of the winter season, generally some time in March. It has been shown that the ascospores can infect the spurs at least nine weeks after the twigs have been pruned, so that spurs left after a pruning in March are susceptible to infection by spores liberated in April and May, and in all probability to those liberated later than this.

The inoculation experiments carried out with *Plowrightia* and *Nectria* indicate that the latter does not prepare the way for secondary infection by *Plowrightia*.

Massee concludes that the death of the twigs is due to a plugging of the vessels, and the present writer has observed vessels almost completely filled with the wide hyphae of the fungus. Frequently, however, the wood appears to be relatively free from mycelium, though this is always abundant in the pith and phloem, and it appears possible that some toxic action of the fungus is responsible, at least in part, for the death of the host tissues.

With regard to the three isolated cases recorded of field observations of natural infection of branches which were not pruned nor connected with diseased branches, it is probable that these were in a weakened or dying condition through some acuse, and became infected through a wound. Two of the three bore large scars where lateral branches had fallen off, and the third had a twisted top characteristic of aphid injury. The experiments recorded above demonstrated that moribund branches can be infected by ascospores through wounds and it is probable that this had occurred in these three diseased twigs. It is possible, as Massee suggests, that aphid or scale injury may be associated with infection in certain cases; however, direct infection through pruned spurs appears to be the usual method in nature. The presence of aphids or scale was rarely noted in the orchards kept under observation during two summers, while the disease became widely distributed.

Cultural Work.

When sections of sterilised stromata were plated out by the method already described for the preparation of pure cultures of the fungus, a profuse mycelial growth was obtained upon red currant wood-extract agar, and from which numerous oval

conidia were abstricted. These cultures agreed closely with the descriptions given by Brefeld (*loc. cit.*), and his account of gemma formation by the spores was likewise confirmed.

The nature of the medium employed was found to exert considerable influence upon the method of germination of the ascospores. In distilled water, numerous conidia were abstricted from either end of the spore and at the septum, but germ tubes never developed. On red currant wood-extract agar, and in beer-wort, hyphae were formed at one or both ends of the spore. If from one end only, it was invariably the larger of the two cells which germinated; if from both ends, the larger cell began to germinate before the smaller. Frequently hyphae arose laterally also. Conidia were usually abstricted after germination had begun, in numbers varying considerably with the strain employed. Ascospores germinating in agar plates in Petri dishes gave rise to circular, white, mycelial colonies which produced enormous quantities of conidia for a time, after which the hyphae continued to grow purely vegetatively and bore no more conidia (Plate VI, fig. 7). Conidia plated out in a similar medium gave rise to somewhat similar colonies if germinating within the agar; if, however, the conidia germinated on the surface of the medium, a circular, white colony developed at that point, consisting entirely of mucilaginous bud spores, and no mycelium, somewhat resembling a bacterial colony and increasing in size up to several millimetres in diameter (Plate VI, fig. 8).

Attempts to produce mature fructifications in culture, with perithecia and ascospores, were unsuccessful. At ordinary laboratory temperatures, the cultures on red currant wood-blocks consisted of a dense, fluffy, mycelial growth, olive-green in colour, in which there developed later certain black, elongated, club-shaped structures (Plate VII, figs. 9 and 10, *c*), sometimes forked, and up to three millimetres in length. These were composed of dark coloured, densely woven hyphae, but developed no trace of perithecia. Cultures on red currant wood with a one per cent. solution of glycerine, on potato and carrot chunks, and on potato chunks with one per cent. glycerine gave no better results, only mycelium developing on the last three media. It was observed that at lower temperatures these organs assumed a more compact form, the microscopic structure closely resembling that of a natural stroma, consisting of a fairly compact, dark-walled parenchyma. Young cultures were therefore placed on the roof of the laboratory for six weeks or more during January and February and exposed to temperatures falling as low as 10° F. At the end of this time, black, oval, or hemispherical pustules had developed with a definitely papillose surface and an internal structure similar to that of a natural stroma, showing

a slight differentiation of thin-walled chambers comparable to the early stages of development of the perithecia (Plate VII, fig. 11, *p*). No further development of these bodies was, however, obtained, either from single spore cultures or from various combinations of these. Occasionally the bodies gave rise to a slimy, white mass of bud spores (Plate VII, fig. 9, *b*), which arose from the tips of thick hyphae at the surface of the organs, in a manner similar to that described by Tulasne (*loc. cit.*), where stout conidiophores arising from the black pustules of the fungus abstricted conidia in great numbers.

These club shaped organs appear to be similar to certain branched, stalk-shaped bodies obtained in cultures of *Brachysporium Trifolii* by Lee Bonar (7). Some of these bore conidiophores and conidia at the tip, while others formed an internal differentiated region comparable with the development of perithecia in the Pyrenomycetes. As with the *Plowrightia*, however, no asci nor ascospores were produced.

Spore Liberation and the Mechanism of the Ascus.

Since infection of the currant is brought about by the ascospores of the fungus, it was essential to know how and when these are liberated. Portions of bark bearing mature perithecia were placed in Petri dishes containing damp filter-paper and a glass ring of the type used for hanging-drop cultures, about half an inch in diameter, was placed round each fragment of bark and a coverslip laid across the top. After several hours the coverslips were removed and examined under the microscope, when quantities of ascospores were found to have collected on the under surface of the glass. Mature perithecia placed similarly in Petri dishes, but kept dry, retained their spores indefinitely, the coverslips remaining without spores for weeks. Subsequent addition of moisture invariably produced a copious ejection of spores on to the glass; it was therefore evident that moisture was essential to spore liberation, as, for example, with the chestnut blight fungus, *Endothia parasitica* (8), and the apple-scab fungus, *Venturia inaequalis* (9).

In order to study the actual process of spore discharge from the ascus, moistened stromata were crushed on a glass slide as soon as spore discharge had begun, and numerous ripe asci were obtained in this way lying freely and intact in a thin film of water under the coverslip. It subsequently appeared that the ascus wall consists of two layers, the outer exceedingly thin and more or less inextensible, the inner relatively thick, capable of great extension and of swelling up enormously on coming into contact with water. The two layers are, however,

indistinguishable in the mature ascus until the process of spore discharge begins.

After some minutes of immersion in water, the outer of the two walls ruptures suddenly at the tip, and the inner wall with its contents immediately pushes through the aperture, elongating rapidly in sudden jerks, with a forward sliding motion, until in a few minutes it has extended to two or three times the original length of the ascus (Plate V, fig. 4, *a*, *b*, *c*). No appreciable increase in width, however, occurs. The ascospores are carried up in the process of elongation and come to lie in a single irregular row throughout the length of the ascus, the uppermost usually situated right at the apex, and the lowest wedged in the short basal stalk whence it is frequently not dislodged. When the extension is complete, a pause of several minutes follows; the apex of the inner wall then suddenly ruptures and the tip of the first spore is forced through the small hole formed at the apex (Plate V, fig. 4, *d*). Prior to the rupture, a slightly thinner area in the wall can sometimes be discerned at this point, and this occasionally swells up into a tiny, knob-like protrusion before bursting. The form of the ascospore evidently plays a part in the discharge which follows. The spore is two-celled, the upper cell being longer and broader than the lower; each is pear-shaped, with the pointed ends forming the poles of the spore (Plate V, fig. 4, *d*). Hence the greatest width comes about halfway between the poles and just above the septum. The spore is gradually forced out of the opening until the maximum diameter is reached, when it is shot out from the ascus with considerable violence and is replaced immediately by the second spore. The performance is then repeated for each spore, the eighth frequently remaining fast in the basal stalk. The spores follow one another at intervals of one or more seconds, and sometimes a definite contraction and re-elongation of the ascus may be observed after each successive discharge. As the last spore is shot out the ascus collapses, shrinking rapidly to about two-thirds of the maximum length, while at the same time the inner wall swells up as if gelatinous, until only a very narrow lumen remains (Plate V, fig. 4, *e*). In order to determine what takes place within the perithecium containing numerous, closely crowded asci, longitudinal sections of mature stromata were cut by hand, mounted in water and examined under the microscope. The ripe asci were packed closely together, arising from a pad of small, thin-walled, hyaline cells at the base of the perithecium and extending to the roof of the chamber. As soon as spore discharge began, the asci upon elongation pushed up through the narrow ostiole and protruded above the surface of the stroma to a distance of about one-third of their total

length (Plate V, fig. 5). After the spores were expelled, the empty ascus shrank back completely within the perithecium, and was replaced by another about to discharge its spores.

Entire stromata which had been moistened and from which spores were being copiously liberated, were viewed in profile under the low power of the microscope. The tips of the elongating asci could clearly be seen emerging from the papillose mouths of the perithecia, the walls of the ascus being sufficiently transparent to reveal the spores lying within. As soon as the tip ruptured, the spores were shot out in rapid succession, as fast as one could count, and without any appreciable pause. Usually all eight spores were ejected, the ascus giving a backward jerk as each spore left the opening, and shrinking back within the perithecium as the last spore was expelled. Generally only one ascus projected from the ostiole at any given moment, though occasionally two or even three were observed together occupying the mouth of the perithecium. Presumably a similar process occurs under natural conditions.

A further method was devised in which stromata were moistened and placed within a glass ring with a coverslip laid across the top. Spores shot upwards from the perithecia adhered to the coverslip and could be observed under the low power of the microscope arriving on the glass surface as glistening bodies on a dark ground and giving a very pretty effect. The shortest interval observed between the moistening of the stromata and the onset of spore discharge was twenty minutes. The rate of discharge was slow at first, but rapidly increased until after an hour or so had elapsed, and spores were being liberated in great quantities. By frequent changing of the coverslip, the position of each spore could be noted. The spores arrived in small groups, the members of a group following one another in rapid succession, and presumably representing the contents of a single ascus. A considerable divergence was observed in the direction of the spores expelled from any one ascus, the maximum distance observed between two such spores on a coverslip placed five millimetres above the mouths of the perithecia was estimated at about 0·5 mm., or twenty times the length of the spore. Groups of eight were rarely observed. This may have been due to the fact that all eight spores were not discharged from the ascus, or, more probably, that they were not all discharged with sufficient violence to reach the coverslip. Possibly, also, the divergence in direction between the spores was so great that some were erroneously not included in the group in question.

The maximum vertical height to which the spores were shot was determined by superimposing two or more glass rings of

varying depth and placing a coverslip across the top. This distance was estimated at about one centimetre, which agrees with similar measurements made by Aderhold (9), with the ascospores of *Venturia inaequalis*. The maximum horizontal distance to which the spores were projected was found to be about three centimetres.

The violent ejection of spores from the ascus is quite a common feature in Ascomycetes, though in many cases the eight spores are expelled simultaneously in a single mass. The successive discharge, such as that described above, is known to occur in some forms, chiefly among the Pyrenomycetes. Pringsheim (10) reports an almost identical process of spore discharge in *Sphaeria Scirpi*, and Hodgetts (11) in *Leptosphaeria acuta*, where, however, actual ejection of the spores did not occur when the asci were submerged in water. Aderhold (9) speaks of asci which elongate prior to spore discharge in *Venturia inaequalis* and *V. pirina*. Lindau in Engler and Prantl (12), gives the presence of a double wall as a character of all members of the Pleosporaceae, which group includes *Leptosphaeria*, *Sphaeria* and *Venturia*. Tubeuf (13) describes a similar spore discharge mechanism in *Cucurbitaria Laburni*. Further mention of elongating asci is made by Zopf in *Sordaria* and Klebahn in *Mycosphaerella punctiformis* (14), and it is possible that this type of spore discharge may prove to be a common feature of the Sphaeriales, a group to which all these forms belong. In any event, it is of interest to find an identical method of spore discharge in *Plowrightia ribesia*, which is classed among the Dothideales, and suggests a possible close relationship between these two groups.

That the spores are liberated in nature only after rain was demonstrated by clipping glass coverslips on to diseased twigs over the stromata. These received a copious deposit of spores after the branches had been wetted by a rain shower, but received no deposit in dry weather.

Since the asci project beyond the mouth of the perithecium prior to spore discharge, the spores are of necessity ejected into the air, and are presumably disseminated by wind. As they are liberated only in moist weather, suitable moisture conditions will be present for their immediate germination provided that they alight upon a suitable host before sufficient time has elapsed for its surface to dry up again. This method of spore liberation appears therefore to be adequate in all respects and highly favourable to the spread of the disease.

The actual mechanism of dehiscence of the ascus and of spore ejection is in all probability due to the development of a very high turgor pressure within the ascus. It is significant that the

process occurs only in the presence of abundant moisture. Water presumably passes through the walls into the cell and raises the internal pressure until the rigid outer wall can no longer withstand the strain and ruptures at the point of least resistance. The external pressure on the inner wall is now released, and as this consists of an extensible material, rapid elongation follows. If water continues to be absorbed through the inner wall of the ascus, the breaking point of this will eventually be reached, and rupture will occur at the weakest point, *i.e.* the apex. Treatment of the mature ascus with Schultze's solution causes a definite shrinkage, the wall swelling up somewhat, the increase in width being uniform except at the apex. Here a small area at the extreme tip remains relatively thin (Plate V, fig. 6), while the adjacent portions become thicker than elsewhere. A similar irregularity in width was observed in the walls of very young asci, suggesting that there is a weaker region at the tip which would account for the rupture always occurring at that point. Tubeuf (*loc. cit.*) and Hodgetts (*loc. cit.*) figure similar variations in thickness in the ascus wall in *Cucurbitaria Laburni* and in *Leptosphaeria acuta*.

The violent expulsion of the spores may be due partly to the high pressure set up within the ascus and partly to a lateral pressure exerted through the elastic contraction of the rim of the aperture. Attempts made to differentiate the two layers in the wall of undischarged asci by stains were not successful, though these showed clearly in the collapsed asci after discharge, particularly when mounted in Congo red.

Conclusions.

Infection of the currant by the fungus *Plowrightia ribesia* is brought about by ascospores liberated into the air in early summer by means of a highly specialised mechanism of spore discharge, and disseminated chiefly by wind. Infection takes place mainly through spurs left in pruning, the fungus acting as a weak wound parasite. Normal, healthy branches are not susceptible to infection, though dying branches may be infected by artificial inoculation.

The disease is of common occurrence in English orchards, and, though not usually of great severity, causes a reduction in yield due to the loss of certain of the branches, and may even occasion the death of the entire bush. The control measures to be recommended are simple, namely, to prune back to the surface of the parent branch instead of leaving "snags," and to cut out and destroy all infected branches, since these serve as a place of over-wintering for the fungus and as a source of inoculum the following season. Cultural practices which tend

to keep the bushes in a healthy and vigorous condition are also of value.

I wish in conclusion to record my thanks to Mr F. T. Brooks for his advice and constant supervision of the work, and to Mr W. Tams, who took the photographs here reproduced.

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EXPLANATION OF PLATES IV–VII.

All drawings were made with the aid of a camera lucida.

Plate IV.

Fig. 1. Dead stems of currant infected with *Plowrightia ribesia* and bearing mature fructifications of the fungus. (*a*) black currant, (*b*) and (*c*) red currant. Slightly reduced.

Plate V.

Fig. 2. Radial longitudinal section of diseased stem of red currant showing mycelium (*m*) of *Plowrightia ribesia* in the xylem and pith. *x*, xylem; *p*, dead pith cells. × 300 approx.

Fig. 3. Tangential longitudinal section of diseased stem showing mycelium (*m*) in medullary ray. × 300 approx.

Fig. 4. Stages in spore discharge from mature ascus in water:
(*a*) Mature ascus before elongation.
(*b*), (*c*) Stages in elongation.
(*d*) Commencement of spore discharge.
(*e*) Collapsed ascus after discharge, showing swollen inner wall of ascus. × 100 approx.

Fig. 5. Longitudinal section through mature perithecium showing elongation of asci in water. × 70 approx.

Fig. 6. Mature ascus after treatment with Schultze's solution, showing irregular thickening of wall at apex. × 225 approx.

PLATE VI.

Fig. 7. Development of colonies from ascospores on red currant wood agar. Slightly reduced.

Fig. 8. Development of colonies from bud spores on red currant wood agar. (*a*) surface colony consisting entirely of bud spores; (*b*) submerged colony of mycelium bearing conidia. Slightly reduced.

PLATE VII.

Fig. 9. Mycelial culture on sterilised red currant wood, kept at room temperatures, showing development of club-shaped organs at (*c*), and masses of bud spores arising from similar organs at (*b*). Slightly reduced.

Fig. 10. Younger culture showing mycelial growth and developing club-shaped organs at (*c*). Slightly reduced.

Fig. 11. Mycelial culture after six weeks' exposure to low temperatures on roof of laboratory. Perithecial body at *p*. Slightly reduced.

STUDIES IN ENTOMOGENOUS FUNGI.

XII. PEZIOTRICHUM LACHNELLA; OPHIONECTRIA COCCORUM; VOLUTELLA EPICOCCUM.

By T. Petch, B.A., B.Sc.

(With Plate VIII.)

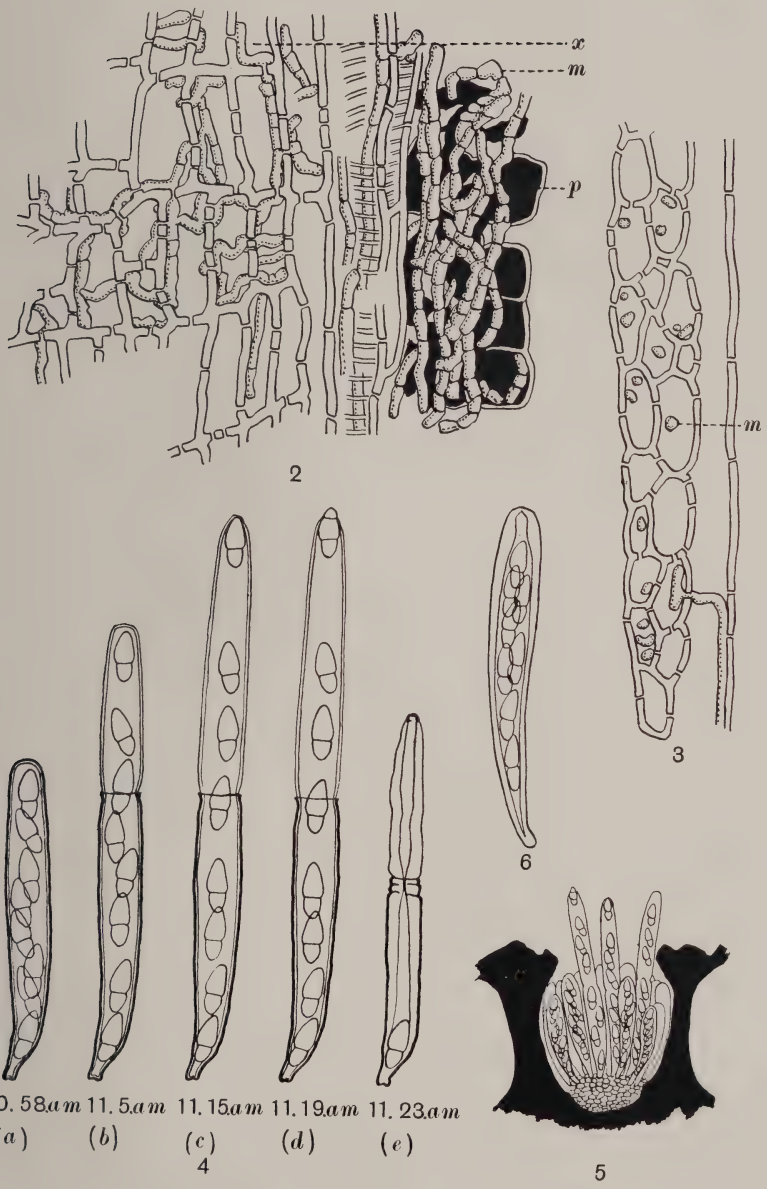
THE three fungi dealt with in this paper are so remarkably similar in general appearance that a genetic relationship between them is immediately suspected. As regards two of them, this has been established by a series of specimens, but no link has yet been found between these and the third. Endeavours to obtain pure cultures have proved abortive.

Peziotrichum Lachnella Sacc.

Parkin in 1906 described a Hyphomycete which was found by Mr E. E. Green on *Hemichionaspis aspidistrae* on a palm at Peradeniya, October, 1899, and on *Aonidia* sp. on leaves of *Memecylon* at Elephant Pass, Ceylon. He referred it to the genus *Peziotrichum* Sacc. I have specimens of both those collections, and others on *Hemichionaspis aspidistrae* on *Fagraea zeylanica* from Peradeniya, and on a Diaspid on *Bambusa* sp. from Malabar (India).

In the specimens on *Hemichionaspis* (Plate VIII, fig. 1) the fungus forms a thin, brown mat over the scale, and spreads out in radiating hyphae closely adherent to the leaf, thus forming a thin, byssoid, rufous-brown stroma, up to 2 mm. in diameter. The marginal radial hyphae of the stroma are rather widely separated, straight, septate, dark yellow-brown, 4–7 μ diameter: they branch at an acute angle, the branches being also

I
Plowrightia ribesia.



Plowrightia ribesia.

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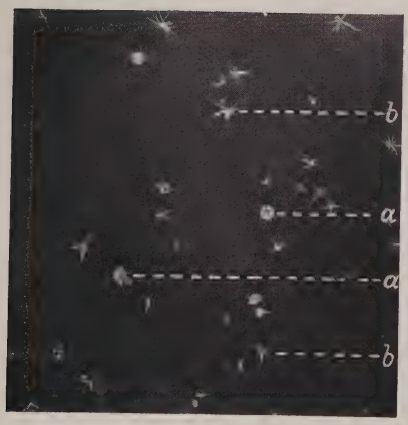

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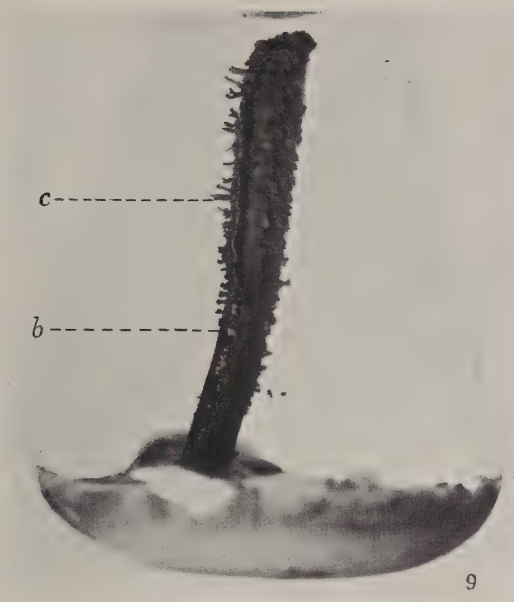
Plowrightia ribesia.



Plowrightia ribesia.

directed radially. In addition, these main hyphae give off curved or flexuose lateral branches, which may remain short and simple, or may branch repeatedly, and by the interweaving and fusion of these branches the radial hyphae are united into a continuous stroma. Some of the flexuose hyphae diminish to a diameter of 2 μ.

The branches frequently terminate in spore-like bodies (Plate VIII, fig. 2), either globose, 14–18 μ diameter, or oval, 18–20 × 14–16 μ, yellow-brown, usually thin-walled. In some cases, these bodies are thick-walled, or the wall may be thick at the base and become thin over the distal hemisphere. These bodies lie in the stroma among the interwoven hyphae. They are somewhat scattered along the individual hyphae, but appear more crowded when the stroma is viewed as a whole, owing to the intermingling of the branches from adjacent hyphae.

Round the edge of the scale there arise numerous, erect, rigid, dark rufous-brown setae (Plate VIII, fig. 5). These are up to 2 mm. high, 4–10 μ diameter, yellow-brown or blackish brown, septate, thick-walled. In general, the apex is slightly inflated, elongated oval, thin-walled and hyaline, as if immature, but some setae are attenuated above and terminate in an acuminate tip. These setae arise singly from the repent hyphae, and fuse laterally into terete fascicles, tapering upwards, 20 μ diameter, or into triangular fascicles, 200 μ broad at the base. When the scale insect is clearly visible, *i.e.* when there is only a slight covering of hyphae over the scale, the fascicles of setae are situated in an oval or circle round the margin of the scale; but if the insect is covered by a denser stroma, they may arise anywhere on the stroma.

The fungus consequently consists, in general, of a byssoid stroma overlying the scale, a ring of setae round the periphery of the scale, and an extension of the byssoid stroma over the surrounding surface of the leaf. The spore-like bodies lie principally in the stroma, external to the ring of setae.

The specimen from Elephant Pass agrees in all essential details with those from Peradeniya. The stroma, however, is denser, and does not extend so far over the leaf. For that reason, the globose bodies are not so readily seen. The differences are no doubt due to the locality, Elephant Pass being in the dry zone of Ceylon.

Saccardo instituted *Peziotrichum* as a subgenus of *Botryotrichum* in 1893 (*Hedwigia*, XXXII, p. 58), stating at the same time that it should probably be regarded as a new genus. It was apparently raised to generic rank by Lindau in Engler-Prantl, *Pflanzenfamilien*. The fungus on which the genus was founded occurred on living branches and spines of *Bursaria*

spinosa, in Victoria, Australia. Saccardo stated that the fungus recalled *Lachnella barbata*, and hence he named it *Botryotrichum* (*Peziotrichum*) *Lachnella*. His description and figures leave scarcely any room for doubt that the Ceylon fungus is the same species. He gave the height of the sterile hyphae, or setae, as 0·7 mm. only (Parkin gave 0·8–1 mm.), their diameter as 3–4 μ, and the "conidia" as 12 μ, subhyaline. The Ceylon specimens have stouter setae and larger "conidia," the latter being hyaline at first.

Saccardo's figure of the fungus, natural size, shows minute groups of setae on the stem, etc., of a living twig. His enlarged figure of the whole fungus shows erect setae arising round a bare oval space. This second figure was copied into Engler-Prantl, and modified in such a way that the copy gives quite an erroneous idea of the fungus. Regardless of the first figure, which shows the fungus on a living branch, the copyist added to the second figure a piece of wood as a substratum, and by so doing completely altered the perspective of the drawing. The oval ground plan of Saccardo's figure becomes an elevation in the copy, so that the fungus is represented as a pulvinate mass, surrounded by setae; and this appearance is heightened by the introduction of a slight bend in the proximal setae at the level of the upper edge of the apparent stroma. A copy of Saccardo's figure is given here (Plate VIII, fig. 3), together with his figure showing the setae and the repent basal hyphae with globose conidia (Plate VIII, fig. 4). The fungus does not consist of a central group of conidiophores, surrounded by setae, like a *Volutella*, as suggested by the figure in Engler-Prantl, but of a ring of setae, round a scale insect, with repent hyphae, bearing globose conidia-like bodies, extending outwards over the host plant.

The genus *Botryotrichum*, to which Saccardo referred his fungus, contains a single species, *Botryotrichum piluliferum* Marchal. This has been studied by Blochwitz, who found that the figure of that fungus in Engler-Prantl was incorrect, and the current idea of it was totally different from reality. It has hyaline conidia and conidiophores, and does not belong to the Dematiae, where it has hitherto been placed (Blochwitz, A., *Ann. Myc.* XII (1914), 315–334). But Blochwitz added that no one could doubt, from Saccardo's figures and description, that *Peziotrichum* was exactly the same thing, the mycelium having been described as dark from its general appearance, not after microscopical examination. The latter assumption was scarcely justified, seeing that Saccardo figured the mycelium; and the reference of *Peziotrichum Lachnella* to *Botryotrichum piluliferum* is not correct.

To add to the difficulty of interpreting Saccardo's fungus, Lindau described it in his key as having cylindrical conidia. Consequently, Parkin stated that the Ceylon fungus differed from *Peziotrichum* in having spherical, rather than cylindrical or rod-shaped conidia.

The spherical spore-like bodies do not appear to be conidia. They do not become detached from the hyphae, and they have not been got to germinate. They lie among the hyphae, usually in contact with the leaf, but, nevertheless, they do not appear to be hyphopodia.

Similar globose bodies occur in the fungus figured on Plate VIII, fig. 15. This, which was found on a scale insect on *Calophyllum Burmanni* in the Haliella Forest, Ceylon, forms a thin, dark brown stroma over the insect, with fine strands radiating from it over, and adherent to, the leaf. After a short distance, each strand expands into a small, fan-shaped, byssoid patch, as shown in the figure. Each of these patches then becomes a centre from which new strands radiate outwards, and this is repeated until a great part of the surface of the leaf is covered. Meanwhile, the strands first formed give off hyphae laterally, which intermingle so that a continuous sheet of interwoven hyphae is formed, the original pattern still being evident on a close examination. The colour of the fungus is dark brown or rufous-brown. Its hyphae are similar in colour, shape, and mode of branching to those of *Peziotrichum Lachnella*, but it lacks setae, and its globose bodies are not so distinctly stalked. No fructification has been observed in this species, but it is most probable that it is a *Septobasidium*, and that the globose bodies are probasidia.

Again, similar globose bodies occur in the basal layer of *Septobasidium suffultum* (B. & Br.) Pat. This species overruns scale insects on living twigs, covering the twig, in the early stages of development of the fungus, with a thin, rufous-brown byssoid layer, which is interrupted here and there by circular or oval gaps, each surrounded by erect setae. These gaps sometimes, but not invariably, mark the position of one of the host insects. The setae coalesce into fascicles, but these are not rigid, like those of *Peziotrichum Lachnella*. The repent hyphae of the basal layer bear globose, spore-like bodies, 12–16 μ diameter, which differ from those of *Peziotrichum Lachnella* in being uniformly thick-walled and apparently permanently hyaline. These are probably probasidia.

It seemed probable, from a comparison with the foregoing examples, that *Peziotrichum Lachnella* was a state of a *Septobasidium*, and that the globose bodies represented probasidia, although up to the present no species of *Septobasidium* to which

it could be referred has been found in Ceylon. But it differs from species of *Septobasidium* in its habit. In general, a *Septobasidium* grows uniformly in a continuous sheet over a colony of scale insects, or if it originates at several points in the colony, the separate growths coalesce. But in all the available specimens of *Peziotrichum Lachnella*, each individual insect bears its own small stroma, *i.e.* each insect is attacked separately, and there is no evidence of any fusion of the stromata by the outward growth of the hyphae over the leaf. This difference of habit would not necessarily exclude the fungus from *Septobasidium*, as there is no reason why reduced species of *Septobasidium* should not exist, in which each fructification might be confined to a single insect, as is the rule with *Aschersonia*.

Examination of other collections, however, has demonstrated that *Peziotrichum Lachnella* is a sterile stroma of an *Ophionectria*.

Ophionectria coccorum Petch.

This species was first collected by Mr E. E. Green in 1910, on *Fiorinia juniperi* Green on *Juniperus bermudiana* in the Botanic Gardens, Peradeniya, and has since been found repeatedly on the same group of trees. The insect is usually concealed under a scale leaf, and the fungus spreads from it over the adjacent leaves.

The perithecia are clustered on a dark brown, byssoid stroma, up to 1·5 mm. long, and 1 mm. broad (Plate VIII, fig. 6). The part of the stroma which overlies the insect consists of contorted hyphae, interwoven into a compact continuous mass, from which more regular hyphae spread out over the leaf and form a byssoid film. The latter hyphae are dark brown, rather thin-walled, septate, straight, 5 μ diameter, branching at an acute angle, the branches being straight, or occasionally flexuose (Plate VIII, fig. 7).

The perithecia occur in groups of up to about six, closely congregated but not adherent. They are conoid, up to 0·2 mm. diameter, dark brown, almost black when dry, but subtranslucent when moist, pruinose, with a thick parenchymatous wall. The asci are clavate, up to 100 $\times$ 8 μ, shortly pedicellate, moderately thick-walled, not capitate, and without an apical pore. The mature asci are distinctly green. The paraphyses are stout, 2 μ diameter, branched above, and slightly inflated at the apex. The asci (Plate VIII, fig. 8) are eight-spored, the spores being arranged in a parallel bundle. The ascospores (Plate VIII, fig. 9) are hyaline, linear, tapering slightly at the ends, almost as long as the ascus, 1·5–2 μ diameter, multiseptate.

This is an *Ophionectria* in the original sense. It differs from *Podonectria* in the shape of the ascospores.

From the same stroma there arise numerous erect setae (Plate VIII, fig. 10), up to 1·5 mm. high, which adhere laterally and form terete or conical fascicles. These usually arise near the perithecia. The separate setae are blackish brown, septate, up to 8 μ diameter, with a slightly inflated, hyaline apex, and closely resemble those of *Peziotrichum Lachnella*. The whole stroma with its setae resembles that of the latter species, but examinations of numerous collections from *Juniperus* at Peradeniya failed to show any globose bodies on the repent hyphae.

In 1924, specimens were collected on a scale insect on *Eugenia* at Bandaragama in the low-country of Ceylon. The stromata were well developed, and formed small mats up to 5 mm. diameter, each overlying a scale, the setae being situated in the centre of the stroma. The repent hyphae of the stroma bore globose bodies laterally and the fungus was typical *Peziotrichum*. Some stromata, however, bore perithecia of the *Ophionectria* in addition, and thus established the connection between the supposedly different fungi. The perithecia were usually situated at some distance from the setae; they agree completely with the perithecia of the Peradeniya collections. The majority of the stromata were barren, *i.e.* were *Peziotrichum Lachnella*. Only a few bore *Ophionectria* perithecia.

Attempts to get this species into culture have failed. Ripe ascospores are not frequently met with, but mature, extruded ascospores have been obtained by detaching the stromata from the leaf, placing them on a glass slip in a damp chamber, and supporting a cover glass over them. The extrusion of the ascospores, however, has not been observed to occur in a short time, and consequently many other fungi have an opportunity of developing before they are obtained. This usually happens with the present species, as numerous foreign spores are entangled in the byssoid stroma and the fascicles of setae. Hence mixtures of spores are found on the cover glasses, and it has not been possible to obtain pure cultures. The germination of the ascospores has not been observed. Failure has also attended attempts to obtain material for cultures by dissecting out the contents of the perithecium.

Ophionectria coccorum Petch, n. sp.

Perithecia gregarious, on a byssoid stroma, conoid, about 0·2 mm. diameter, dark brown, pruinose; wall thick, parenchymatous. Asci clavate, shortly pedicellate, thick-walled, up to 100 × 8 μ, eight-spored, the spores in a parallel bundle. Paraphyses stout, 2 μ diameter, branched, slightly inflated at the apex. Spores linear, straight or flexuose, 1·5–2 μ diameter,

nearly as long as the ascus, tapering slightly at the ends, multiseptate, with septa about 6 μ apart.

On *Fiorinia juniperi* on *Juniperus bermudiana*, Peradeniya, Ceylon.

Volutella epicoccum Petch.

Another fungus, which, macroscopically, bears a striking resemblance to *Peziotrichum Lachnella*, has been found at Hakgala (5600 ft.), on a scale (? *Lecanium*) on *Cinnamomum ovalifolium* Wight. It has been collected in that locality on several occasions during the last three years, but only on one tree.

The fungus covers the insect with a compact, plectenchymatous tissue and spreads out in a byssoid film over the leaf, forming a rufous-brown stroma, up to 2 mm. in diameter (Plate VIII, fig. 11). The part of the stroma which overlies the insect is thicker and denser than in *Peziotrichum*, and it is only possible to determine that the fungus is parasitic on an insect by teasing out the tissue and finding the remains of the scale.

At the margin of the thicker part of the stroma, there arise erect setae, up to 1·5 mm. high, which cohere laterally into rigid fascicles. These fascicles are arranged in a ring, as in *Peziotrichum*. The setae and the hyphae of the stroma are similar to those of *Peziotrichum Lachnella* and *Ophionectria coccorum*, but there are no globose bodies on the repent hyphae.

Rounded pulvinate masses occur within the ring of setae. They occur at the base of a group of setae, or in some instances are partly surrounded by setae which cohere above so that the pulvinate mass is enclosed within the base of a fascicle. These masses do not entirely cover the space within the ring, but two or three, clustered or solitary, are situated at its margin, in contact with the setae or partly encircled by them. Plate VIII, fig. 12, shows one of these masses separated from the rest of the fungus.

These pulvinate masses are sporodochia. When dry they are brownish, but white when moist. They are composed of closely-packed vertical conidiophores, brownish at the base, hyaline and branched above. The conidia are hyaline, cylindric, usually curved at one end, sometimes straight, attenuated at the curved end, obtuse at the other, 40–56 $\times$ 3 μ, continuous (Plate VIII, fig. 14).

Other specimens of this species have been collected on *Parlatoria aonidiformis* on *Cullenia excelsa*, at Ratnapura in the low-country of Ceylon, and these show a further development. The stroma grows over the insect, as in the Hakgala collections, in a dark brown disc about 1 mm. in diameter, with a margin of rufous-brown radiating hyphae. Some stromata

bear erect fascicles of hyphae, with pulvinate sporodochia at their bases, as in the specimens on *Cinnamomum*, but, in general, a single column arises from the centre of the stroma (Plate VIII, fig. 13). This column is up to 3 mm. high, and consists of a brownish black stalk, 0·75 mm. diameter below, expanding to 1 mm. diameter above, and terminating in a funnel-shaped head, up to 1·75 mm. diameter, bordered by triangular fascicles of dark brown hyphae, up to 0·4 mm. long. The stalk is smooth, sometimes with a few projecting bristles towards the base, and sometimes with a ring of setae, at a varying height, as though it had grown through a previously formed head lower down. It is composed of parallel hyphae, similar to those of the fascicles of setae in the other collections.

The inner hyphae of the stalk terminate as conidiophores, while the outer form a sheath round the head and extend above it in erect fascicles.

The mass of conidiophores and conidia is white when moist, and both are similar to those of the specimens on *Cinnamomum*, the conidia being somewhat longer, 48–68 × 2·5–3 μ.

No globose "conidia" occur on the basal mycelium.

In the occurrence of both sessile sporodochia and stalked synnemata, this species affords a parallel to *Microcera coccophila*.

The genus *Volutella* includes both sessile and stalked forms. The present species differs from *Volutella* in having a superficial stroma, but that is a consequence of its growth on a scale insect. It also differs from *Volutella* in having the setae adherent in fascicles, and, in its sessile form, in that they are adjacent to, rather than part of, the sporodochium.

Volutella epicoccum Petch, n. sp.

Stroma byssoid, up to 2 mm. diameter, bearing either sporodochia or synnemata. Sporodochia pulvinate, brown when dry, white when moist, accompanied by dark brown setae, up to 2 mm. high, 4–8 μ diameter, coalescent in fascicles. Synnemata terete, up to 3 mm. high, 0·75 mm. diameter below, 1 mm. diameter above, terminating in a funnel-shaped head, 1·75 mm. diameter, the outer sheath produced in elongated teeth, 0·4 mm. long. Conidiophores hyaline, stout, branched. Conidia terminal, solitary, hyaline, linear or narrow-clavate, straight or curved at one end, attenuated at the curved end, obtuse at the other, continuous, 40–68 × 2·5–3 μ. On scale insects, *Parlatoria aonidiformis* and ? *Lecanium* sp.

Attempts to germinate the conidia have been unsuccessful, and it has not been possible to get this species into culture. The general structure of the fungus strongly suggests a relation-

ship to *Ophionectria coccorum*. But, although both species have been collected on numerous occasions, no conidial stage has been found with *Ophionectria coccorum*, and no perithecial stage with *Volutella epicoccum*.

Volutella epicoccum has been collected at Hakgala (5600 ft.) and in the wet low-country, and in neither locality have pseudoconidia been found on the mycelium. *Peziotrichum Lachnella* has been collected at Peradeniya (1600 ft.), Bandaragama (sea level in the wet low-country), and Elephant Pass (sea level in the dry zone); it has pseudoconidia but no true spores. *Ophionectria coccorum* has been collected repeatedly on two contiguous trees at Peradeniya (1600 ft.), but all the collections from this locality lack pseudoconidia; it has also been collected sparingly at Bandaragama (wet low-country) in company with *Peziotrichum*, its stromata in that collection bearing pseudoconidia. Assuming that *Volutella epicoccum* is related to *Ophionectria coccorum*, the data suggest that, in general, pseudoconidia are only produced in the absence of conidia or perithecia.

EXPLANATION OF PLATE VIII.

Fig. 1. *Peziotrichum Lachnella*, Ceylon specimen, entire stroma. × 10.
Fig. 2. *P. Lachnella*, Ceylon specimen, repent hypha with globose bodies. × 300.
Fig. 3. *P. Lachnella*, enlarged figure of entire stroma, after Saccardo. Magnification not stated.
Fig. 4. *P. Lachnella*, enlarged figure of the setae and repent hyphae, after Saccardo. Magnification not stated.
Fig. 5. Setae of *P. Lachnella*, Ceylon specimen. × 300.
Fig. 6. *Ophionectria coccorum* on scale on *Juniperus*, entire stroma. × 20.
Fig. 7. Repent hyphae of *O. coccorum*. × 300.
Fig. 8. Ascus of *O. coccorum*. × 600.
Fig. 9. Ascopore of *O. coccorum*. × 600.
Fig. 10. Seta of *O. coccorum*. × 300.
Fig. 11. *Volutella epicoccum*, entire stroma. × 20.
Fig. 12. *V. epicoccum*, part of stroma with a single sporodochium. × 20.
Fig. 13. *V. epicoccum*, stalked form. × 20.
Fig. 14. *V. epicoccum*, conidia. × 500.
Fig. 15. ? *Septobasidium*, on scale insect on *Calophyllum*. × 7.

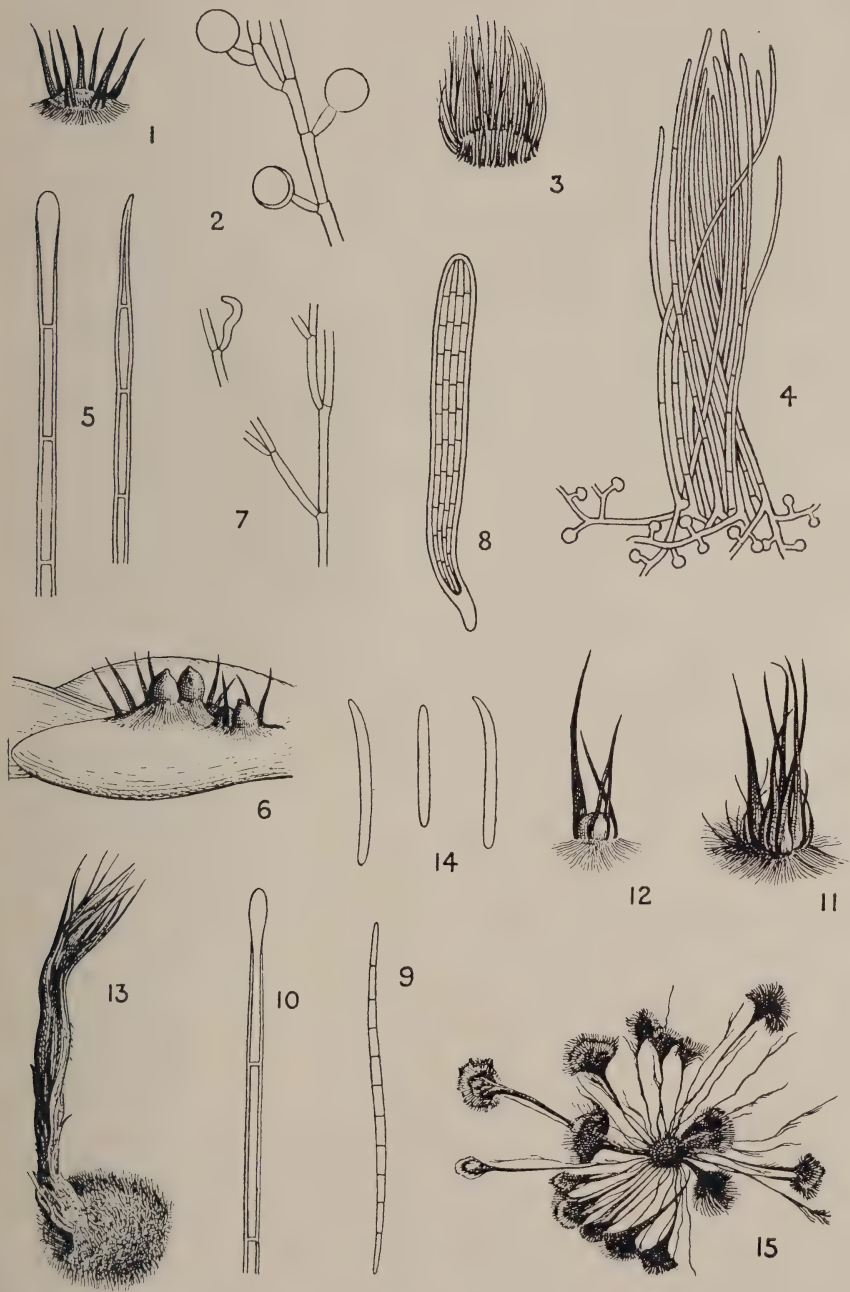
THE SOREDIA OF PELTIGERA ERUMPENS WAIN. AND P. SCUTATA KBR.

By O. V. Darbishire.

(With Plates IX and X.)

Introduction.

The soredium, which is a reproductive organ of the complete lichen, consists of a group of algal gonidia surrounded by a layer of fungal hyphae. The soredia generally occur in well-limited areas which are known as soralia. Following Acharius, however,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du Rietz defines a soredium ((15) p. 376) as a decorticate portion of a lichen in which numerous reproductive units have been formed by the excessive increase of the gonidia. Each reproductive unit consists of a small group of algal gonidia surrounded by a fungal sheath, and is called by him a soredial grain or propagulum. The soredium of Acharius and du Rietz therefore corresponds to our soral, a term first used by the author ((3) p. 320), though originally suggested by Reinke in conversation. The soredial grain or propagulum of du Rietz corresponds to our soredium. Schwendener used the term soredium in our sense many years ago, when referring to *Usnea* ((17) p. 130 and 131). The term soral has now been generally adopted. Quite recently Magnusson said: "I find it practical to keep the much-used and useful term soralia for the distinctly limited places where soredia develop" ((10) p. 13). The term soredium is also very generally used in the Schwendenerian sense.

The ascospore reproduces the fungus only and not the complete lichen. Hymenial gonidia reproduce the complete lichen, but their occurrence is very rare (21). The soredia in fact represent the only common lichen reproductive organ which contains both gonidia and fungus, though a lichen may be reproduced by the breaking-up of the thallus into smaller portions. It is also possible that isidia may act in a reproductive capacity if by chance they get separated from the metathallus on which they are borne. Reproduction, however, is clearly not the main function of the isidium and the thallus fragment. The soredia are the only true reproductive organs of the lichen consortium.

Very little is known of the method of origin of the single soredium. Rosendahl speaks of certain isidia-like outgrowths of *Parmelia verruculifera* Nyl. which break up more or less completely with the formation of soredia ((16) p. 426). The soredia of *Evernia furfuracea* var. *soralifera* Bitter ((2) p. 482), and *Parmelia farinacea* Bitter ((1) p. 177) originate in a similar manner. Schwendener mentions the breaking through of the cortex by the soredia of *Usnea barbata* ((17) pp. 137 and 138), *Evernia vulpina* ((17) p. 160), and other lichens. In a paper on the Pertusariaceae of Germany the author gave an account of the origin of the soralia in *Variolaria globulifera* and *V. amara* ((4) pp. 647 and 656). A mass of hyphae grows up from just above the substratum and by pressure upwards breaks through the cortex ((4) p. 647, figs. 24–26). In a later paper the author described the origin of the soralia of *Roccella fuciformis* (L.)DC. ((5) p. 22) where again the cortex is ruptured by the growth of internal hyphae. The most detailed recent account of the origin of the soredium is that by Moreau ((12) p. 328, figs. 10–13) of *Lobaria pulmonacea* Nyl. Hyphae belonging to the upper

portion of the gonidial layer grow out, whilst the gonidia themselves at first remain inactive. Small groups of gonidia are surrounded by hyphae and are pushed up towards the cortex. In this way the soredia are differentiated and by pressure break through the cortex, the cells of which in the meantime have died off.

Very little is known about the fate of the soredium after it has separated from the parent plant. The author described the growth of some free soredia of *Variolaria globulifera* which were kept under observation for eight months. They measured about 50–60 μ in diameter at the beginning of the experiment, and had reached a diameter of about 520 μ when the experiment had to be concluded. By that time the soredia appeared to have obtained a firm hold on the substratum of cork ((4) p. 658).

Tobler has carried out similar experiments on the germination of the soredia of *Cladonia glauca* Flk. and *Cl. squamosa* (Scop.) Hoffm. ((23) pp. 409–417, Pl. III, fig. 11). In a macro-culture he observed the formation of a primitive *Cladonia*-thallus by the coalescence, as he thought, of several separate soredia. Both Tobler's observations and my own merely show that the soredia are organs of reproduction. The details of the process of germination of the soredium and its subsequent growth to form even a primitive lichen thallus have not yet been recorded.

Schwendener described for *Usnea* what can only be called the germination of soredia *in situ*, that is in the tissue of the soral which has given rise to them. A single soredium may grow out and give rise to what he calls a soredial branch ((17) pp. 137–139; Pl. II, figs. 16, 18–20, 23–24). This can be distinguished from the ordinary or adventitious branch because the cortex of the latter is continuous with that of the main axis, which is not so with the soredial branches. A specimen of *Usnea* which bears numerous soredial branches is thus not a single organism but a multiplicity of individuals ((17) p. 139). Schwendener's soredial branches represent a very extraordinary example of a daughter organism becoming parasitic on the parent thallus. Kajanus makes use of the term "soredial branch" when writing of the isidia of *Peltigera rufescens*, a species which I should probably call *P. praetextata* ((8) p. 42), but Kajanus draws no sharp line between soredia and isidia.

Krabbe has discussed at some length the soredia of the genus *Cladonia*. He describes the growth of foreign *Cladonia* soredia which are blown on to the podetia of certain species of *Cladonia* and become fixed to this new substratum ((9) p. 118). The soredia thus blown on to any specimen of *Cladonia* may belong to almost any species of *Cladonia*. In the end only the algae are retained as gonidia by the fungus of the host. The original

fungal hyphae surrounding these gonidia degenerate and die off, so that only the algae are left over from the alien soredia ((9) pp. 126 and 127). It should be mentioned that Krabbe claimed that the upright thallus or podetium of *Cladonia* was entirely a fruit body, and as such, primarily at any rate, bore no gonidia. All the gonidia found on a podetium appear to have come from other specimens except a few which are derived from the gonidia of the protothallus which gave rise to the podetium ((9) p. 115). It is in view of the great importance of the soredium to the lichen, that I have studied in greater detail the soredia of two species of *Peltigera, P. erumpens* and *P. scutata.* These species of *Peltigera* were chosen because I had already investigated the isidia of *P. praetextata* ((7) p. 739).

It is not as yet possible to say what is the full systematic value of the soredium. It is doubtful whether all soredia are homologous structures, or even whether they are all analogous structures. There is no doubt, however, that the soredium of the lichen is polyphyletic in origin.

During an examination of the German species of the Pertusariaceae I laid stress on the presence or absence of soredia for systematic purposes ((4) p. 595), and re-established the genus *Variolaria* Ach. which included those species of *Pertusaria* DC. bearing soredia. There are other differences between these two genera which clearly indicate that, though allied, they should be kept separate, although this separation has not been accepted by lichenologists. To Bitter belongs the credit of having been the first to study carefully the systematic value of soredia. In the course of a systematic investigation of certain species of the sub-genus *Hypogymnia* of *Parmelia* ((1) p. 171 *et seq.*) he made special use of the development and morphology of the soralia for systematic purposes. The presence of soredia is in many cases clearly a definite feature characterising, and thereby separating, certain species, if this term is used in the conventional sense.

Peltigera erumpens and *P. scutata* always bear soredia. They are not merely sorediiferous forms or varieties of species of *Peltigera* which do not necessarily produce soredia. Du Rietz states this quite definitely ((14) p. 210) and I fully agree with him. Many lichenologists look upon sorediiferous individuals as mere biological or ecological forms or varieties and assume that certain conditions must be fulfilled before a species will bear soredia. But certain conditions too must be fulfilled before sorediiferous species like *P. erumpens* and *P. scutata* will grow at all. These two species are not on that account biological species: they are genotypes as regards the property of producing soredia. Moreau looks upon sorediiferous specimens of the genus *Peltigera* as being a more or less direct result of the influence of

the surrounding conditions; that is as being representatives of a species not necessarily bearing soredia ((11) p. 115). Kajanus, too, considers the occurrence of soredia and similar growths as a biological phenomenon depending on more or less accidental external conditions ((8) p. 42).

P. erumpens is recognised as a good species by A. Zahlbruckner ((25) no. 6235). Other lichenologists have looked upon it as a variety of *P. canina* Willd., of *P. rufescens* Hoffm., of *P. pusilla* L., or of *P. spuria* DC. *P. scutata* Kbr. also is recorded by A. Zahlbruckner as a separate species ((25) no. 6251), and this is the status assigned to it by most lichenologists to-day. The soralia of *P. erumpens* are circular in outline. In *P. scutata* they occur in marginal or superficial soralia which are long and narrow. In the British Museum Catalogue of British Lichens ((19) p. 92) *P. erumpens* Tayl. is listed as var. *erumpens* Hue of *P. canina* Willd. It is recorded from Dunkerron, County Kerry. I have found it near Thirlmere. *P. scutata* Kbr. is recorded in the same catalogue ((19) p. 94). It is a fairly common British species. Olivier records a forma *sorediata* of *P. rufescens* ((13) p. 158). Not having seen specimens of this form I cannot say whether it is really sorediiferous, but judging by his description of the variety *praetextata* of *P. rufescens* which he also refers to as sorediiferous, it is possible that he does not distinguish clearly between isidia and soredia. Sydow obviously does not separate soredia and isidia as he assigns the presence of marginal scales and soredia to the variety *praetextata* of *P. rufescens* ((22) p. 59), though *P. praetextata* never bears soredia, but isidia only. He also characterises the forma *crispata* of *P. canina* as possessing marginal soredia which again is incorrect. The structures found at the margin are either closely set lobes of the ordinary thallus or true isidia. In the latter case his f. *crispata* is a synonym for *P. praetextata*. A. Zahlbruckner seems to be of the same opinion though he places *P. praetextata* as a variety of *P. rufescens* ((25) no. 6249). Bitter finds that in *Parmelia farinacea* Bitter the isidia produce soredia at their tips. This process he suggests might be looked on as a transition from the isidial to the soredial formation. He is nevertheless of the opinion that isidia and soredia should be kept separate ((1) p. 177) and is therefore misquoted by Rosendahl who states that in Bitter's view no sharp line can be drawn between isidia and soredia ((16) p. 31), and Smith ((18) p. 143). I do not wish to pursue the matter further here, but will again refer to du Rietz who recognises as distinct sorediiferous species of *Peltigera* only the two species just mentioned, namely *P. erumpens* and *P. scutata*, just as he recognises only two isidiiferous species, in *P. praetextata* and *P. lepidophora* ((15) p. 382). He makes here

full use of isidium and soredium for systematic purposes and also draws a sharp line between isidium and soredium.

Methods.

The methods adopted in preparing the material for this paper were simple. Fixation was by absolute alcohol or weak Flemming. The microtome sections were cut in the usual way after passing the material through cedar wood oil and hard paraffin. Sections were stained with fuchsin and mounted in glycerine jelly.

The Structure of the Metathallus of *P. erumpens*.

(Figs. 3 and 4.)

The structure of the metathallus of *P. erumpens* differs but little from that of *P. canina* ((6) p. 17, fig. 1). The thallus is on the whole less coarse and thick but the same tissues are found in both species.

The following measurements obtained for the various portions of the metathallus of *P. erumpens*, are here compared with those of *P. polydactyla* Hoffm. ((7) p. 731), which are given in brackets. The cortex of *P. erumpens*, 40 to 50 μ deep (30 to 40 μ in *P. polydactyla*), is made up of the usual vertical rows, composed of 2 to 3 (2 to 4) cylindrical cells with a diameter of 10 to 20 (5 to 18) μ. Each cell may be 10 to 24 (up to 24) μ or even 28 μ in height. The walls are of a uniform thickness of 2 (1·5 to 2) μ, the total wall substance separating two neighbouring cell cavities thus amounting to 4 (3 to 4) μ. Over a distance of 100 μ the cortex of *P. erumpens* has about 9 (10) cells, and is normally quite uninterrupted. The cortical cells of *P. erumpens* are characterised by their large size and uniform roundness, while those of *P. polydactyla* are more angular. The actual surface of the cortex of *P. erumpens* is uneven, though not actually rough or scabrid.

The gonidial layer is 60 to 80 (60 to 80) μ deep, and consists of short threads of *Nostoc* cells measuring about 4 to 8 (4 to 10) μ in diameter and embedded in a clear mucilage to a depth of about 1 to 2 (2 to 3) μ. The intergonidial hyphae are delicate, measuring 2 to 4 (5 to 6) μ in diameter, and finer branches sometimes actually enter the gonidial mucilage. Air spaces are found separating the intergonidial hyphae. The *Nostoc* groups are closely surrounded by the intergonidial hyphae, though in the lowest portions of the gonidial layer the mucilage is often quite free of any hyphae, thus becoming fully exposed to the air circulating inside the metathallus. Hyphae run from the cortex right through to the hypothallus, though they are not so frequent as in *P. polydactyla*.

The medullary hyphae can be divided into infra-gonidial hyphae, the measurements of which vary very much, their diameter being on the average about 6 (4 to 6) μ, and the special conducting hyphae which run in well-developed strands up to 40μ in thickness. The separate hyphae have a diameter of about 16 (8 to 10) μ. The hypothallus is not on the whole very well marked and it varies very much in depth, which does not exceed 20 (80 to 100) μ. The separate hyphae measure 6 (5 to 6) μ in diameter, of which a total of 4 (4) μ is due to the two walls. The total thickness of the thallus of *P. erumpens* does not exceed at the most 0·4 mm., while usually it is uniformly 0·35 mm. thick (0·5 to 0·55 mm.).

The rhizines, generally short and very thin, do not exhibit the clear differentiation between inner conducting hyphae and outer hypothallus-like hyphae which we find in *P. praetextata* and other species of *Peltigera*. In *P. erumpens* all the hyphae of the rhizine run in a more or less longitudinal direction. The hyphae of the metathallus bend out into the rhizine just as they do in the larger species, that is in such a way that they cross over to the opposite side of the rhizine before taking a strictly longitudinal direction. The rhizine is about 70 to 80μ in diameter, a single central hypha measuring 10μ across, while the wall is about 3μ thick. At the periphery of the rhizine the hyphae, which are still running in a longitudinal direction, measure 5 to 6μ across, with walls whose thickness is 2μ. The hyphae are firmly cemented together and cross-pieces or struts can be seen, though they are far rarer than in *P. praetextata*, *P. canina* and others. The inbending of the free apex of the rhizinal hyphae to form the struts is rarely observable ((7) p. 734). The hyphae of the rhizines of *P. erumpens* probably spread out in the sandy or loose soil and possibly absorb water more by the functioning of the thick walls than by the working of numerous intercellular air spaces which are less extensive than in other species. *P. erumpens* does not form big strong rhizines, which are so characteristic of the larger species.

Cracks, so-called, occur in the cortex of *P. erumpens*, though they appear to be rare. I have seen them in a few instances but they had all been healed over. Hyphae had grown up from the infra-gonidial layers and the wound was completely closed by a continuous covering extending from cortex to cortex. In one specimen, gonidia were gradually filling up the gap in the gonidial layer by an extension from the neighbouring portions of the layer. The breadth of this scar, which measured 0·35 mm. across, seemed to indicate that the break in the cortex had been brought about by the attacks of some small marauding animal, rather than by some mechanical agent, as so commonly occurs

in other species of *Peltigera*. I have referred to the wound and its healing over in order to point out that a break in the cortex does not necessarily lead to the formation of soredia.

The Soredia of *P. erumpens*.

Soralia occur in *P. erumpens* in the form of circular interruptions of the cortex (Fig. 1). They are of a lighter colour than the metathallus. The smallest soralia are found nearer the margin and the largest and oldest nearer the centre of the thallus. It is clear that the soralia originate near the margin. In this region very closely interwoven hyphae which are branches from the longitudinal medullary hyphae may be noticed here and there in the inter-gonidial and infra-gonidial layers. Air spaces are almost absent from this tissue at this time. The few hyphae of the future soral grow upwards towards the cortex and push their way into it, thereby making a break in the continuity of the primary cortex (Fig. 3). No open wound is formed by which the underlying tissues become exposed. All the evidence I have collected points to the fact that the initial hyphae of the soral themselves cause the break in the cortex rather than that the continuity in the cortex is interrupted by external mechanical means.

The initial hyphae can be readily distinguished from the ordinary cortical cells, as the latter are larger and the regular course of the single cell row is often lost. In the initial soralial hyphae which have forced their way into the old cortex the course of the cell rows can be made out very clearly (Fig. 3). It appears that the function of the soralial hyphae is to interrupt the continuity of the old cortex in order to allow the main tissue of the soral to come to the surface (Fig. 4). The real break in the cortex therefore occurs between the group of initial hyphae and the old cortex. These two tissues are then separated by the new main tissues of the soral. The actual break in the cortical continuity and the initial hyphae can be clearly seen on the sides of the growing mass of main soralial tissue. In later stages the initial hyphae can usually no longer be distinguished (Fig. 2). Whether the main soralial tissue forces its way in between the initial hyphae and cortex or whether owing to growth the formation of a gap is threatened, into which the soralial tissue grows, has not been clearly made out. It is very likely that both conditions co-operate. In any case no open wound is formed (Fig. 4).

The main soralial tissue consists of branched hyphae which are based on the infra-gonidial longitudinal medullary hyphae, and run mainly towards the cortex, forming a very close plectenchyma (Fig. 4). Air spaces are few, except near the

lower ends of these hyphae where they arise from the infra-gonidial layers. The outer covering cells form a continuous layer which acts as a protection for the underlying gonidia.

The activity of this main soralial tissue is almost the same in the young and in the old soral where it forms a more or less continuous, though often uneven, layer over the whole soral. In quite old soralia, the continuity of this actively growing layer may be interrupted but never in such a way as to expose the gonidia to the possibility of desiccation (Fig. 2). It is impossible to say at which point the separate hyphae of the growing soralial tissue are most actively dividing. The cells, on the whole, are short, and new cell formation therefore in all probability proceeds along the whole length of each hypha.

The following is the course of development of a single soredium and of its gradual differentiation into a separate unit from the general tissue of the soral (Figs. 4 and 5). Branches arise from the medullary hyphae and grow in between the lower groups of gonidia. At this point these groups are round or oval in shape, and generally are partly exposed to the air, like all the lower gonidial groups in the metathallus (Figs. 4 and 5). The branches of the medullary hyphae grow so as to separate the groups of algae which lie close together and to surround these smaller groups by a continuous fungal sheath. Larger groups apparently may be broken up. The hyphae at first run in various directions (Fig. 5), but gradually straighten themselves out as they grow towards the upper surface of the soral (Fig. 5). The gonidial groups also alter their shape in conformity with the straightening of the hyphae. The gonidial groups become elongated as they move along with the hyphae. The algae must be growing actively as their groups consist of more cells as they approach the upper surface of the soral. Air spaces are few in this part of the soral and are probably very small, so that they are generally overlooked.

Near the surface of the soralial tissue the soredia now begin to be differentiated, the first indication of the coming differentiation being visible on the actual surface (Fig. 5). A slight projection is formed immediately above the group of algae which is going to form the gonidial element of the soredium. The projection becomes more distinct, and from being only a few cells broad it gradually becomes bigger. At first the projection with its underlying gonidial groups is very much longer than broad and becomes more rounded as it separates from the main mass of the soralial tissue. In conformity with this change in position of its surrounding hyphae each gonidial group assumes a more rounded shape. Gradually the little mass of tissue which was capped by the projection becomes almost freed from the main

tissue as it is pushed up by a number of single hyphae (Figs. 6 and 7). It is by these single hyphae that the now almost completely separated soredium remains in touch with the parent plant. Laterally the soredium may be in close touch with its neighbouring sister soredia but there is no actual connection between them. The cells of the lower hyphae which form what we might term the stalk of the soredium grow in width and length and are evidently pushing the soredium up. These cells gradually assume a barrel shape and by a split in the transverse walls the soredium is ultimately completely separated from its parent plant. During the last stages the gonidia have become more active and even the smallest free soredium contains several groups of gonidia and air spaces begin to make their appearance owing to the growth in length of the internal hyphae (Fig. 8). The outer layers of the soredium act as a protection for the gonidia and they appear at first, at any rate, to be continuous (Figs. 6 and 7). In the irregularly outlined cortex so formed pores are later found by which the outside air can communicate with the air in the rapidly growing air spaces inside the soredium (Figs. 8–10). These pores are formed either by the separation of the cell walls or by the want of coalescence when new hyphae are interpolated between older cells, similar to the method of origin of the pores on the underside of the isidia of *P. praetextata* ((7) p. 746).

The gradual separating out of the single soredium from the general undifferentiated soralial tissue cannot always be followed out in the way which has just been described. Gonidial activity on the whole keeps pace with hyphal activity—and therefore all stages are found in the differentiation of the soredia from below upwards (Fig. 5). It would appear, however, that gradually all the gonidia at one point are used up in the formation of soredia as one group of gonidia after another has been dealt with basipetally. Hyphal activity may thus in the end exceed gonidial activity so that no gonidia are left at that point (Fig. 2). When this occurs, it is almost certain that, in due course, the gonidia spread to this spot again.

A mature soredium is more flattened in a vertical direction than is a young one, and it shows the following structure (Fig. 8). It is completely surrounded by a cortex, the cells of which clearly show their hyphal origin by being elongate. Their outline is often very uneven and is interrupted here and there by very small pores (Figs. 9 and 10). A clear differentiation of the internal tissue characterises the mature soredium. The gonidial groups have increased in number and fill the inside of the soredium closely. Numerous narrow inter-gonidial hyphae penetrate into the folds of the mucilage of the gonidial groups,

though they no longer completely surround them. Extensive air spaces have again made their appearance and are often directly bordered by the mucilage enclosing the gonidia. In the mature soredium we thus get a primary cortex and gonidial groups which are well rounded off and closely in touch with the intergonidial hyphae. Though the soredia may be slightly flattened it is not possible structurally to differentiate between an upper and lower side.

A mature soral may give a wrong impression as to its origin (Fig. 2). The margin of a soral is made by the abrupt ending of the original cortex of the metathallus. This cortical layer is often thrown back, making it appear as if the soralial tissue had originally burst through the cortex in an irregular way, and so rolling it back as fresh portions of the gonidial layer were broken up into soredia. This, however, is not generally the case. The exposed surface of the soral increases, not by the cortex being continually rolled back, but by the growth of the underlying medullary hyphae and the cortical cells which surround the soral. The cortical margins of the soral are moving away from one another through the growth of the medullary hyphae. These grow in length and the cortical cells grow in diameter. This growth accounts for the extension of the soral. At the same time it is almost certain that the gonidia lying near the edge of the soral but still under the cortex are to a limited extent made use of as material for the differentiation of soredia, and in this way the cortex is rolled back to a limited extent (Fig. 2).

In cultures of *P. erumpens* which had been kept going for more than a year the greater part of the original lichen had apparently died. At its margin it had given rise to small regenerative nodules which seem to occur only in culture and under artificial conditions. I have found these nodules in other species of *Peltigera* which have been kept in cultures under similar conditions. In the culture of *P. erumpens* I found after nine months a number of small soredium-like bodies on the small moss plants over which the original *P. erumpens* plants had been growing. By the end of fourteen months some of these bodies had grown up into small thalli, one of which measured about 2 mm. in length and was about 0·5 mm. broad. At the same time quite small green bodies were found growing on neighbouring moss plants and these appeared to be soredia which must have come from *P. erumpens*. When examined under the microscope one measured about 0·5 mm. across and it was about 0·2 mm. thick. From one point on the underside arose a bundle of hyphae which had grown out to a distance of about 1·3 mm. (Fig. 11). The hyphae exhibited the usual apical

fusions which are characteristic of the growth of the free medullary and rhizinal hyphae of all species of *Peltigera* ((7) p. 734, fig. 10) I have examined. This specimen still possessed a continuous cortex which by the arrangement of its cells recalled the structure of a typical soredium of *P. erumpens*, and circumstantial evidence is strongly in favour of its being so. It has not, however, been possible to observe how the little differentiated soredium passes through the later stages after germination into the much more highly differentiated thallus of *P. erumpens*.

Structure of *P. scutata*.

In structure *P. scutata* resembles *P. erumpens* but the gonidial layer of the latter varies in depth only from 60 to 80μ, whereas that of the former varies from 40 to 100μ. This variation in the depth of the gonidial layer of the metathallus is a very noticeable feature of *P. scutata*. The algal groups are frequently not completely surrounded by fungal hyphae. The medullary hyphae are loosely interwoven and reach a thickness of 4 to 20μ, thus exceeding in diameter those of *P. erumpens*. The most characteristic structure by which we can separate *P. erumpens* from *P. scutata* is found in the light-coloured veins of the former which are very prominent especially after the thallus has been moistened, whereas *P. scutata* has veins which are dark in colour and which, though clearly distinguishable in surface view, are not prominent, while between the veins are the usual lighter-coloured cyphellar gaps. The metathallus of *P. scutata* is on the whole thicker than that of *P. erumpens* the difference amounting to about 0·1 to 0·2 mm. The dark rhizines of *P. scutata* show the internal differentiation which is found in *P. praetextata* whereas the rhizines of *P. erumpens* are light-coloured, and simple in structure. Speerschneider was the first to give an account of the anatomy of *P. scutata* (20).

The Soredia of *P. scutata*.

The soredia of *P. scutata* occur in two kinds of places on the thallus (Figs. 12 and 13). When the protothallus ceases to grow, it may give rise to soredia. This puts an end to further extension of the thallus and the lateral edges of most of these thalline lobes bear soredia. These form a soral which laterally has no bounds. Occasionally the actual growing margin may give rise to soredia. Soredia also occur on the surface of the thallus in long narrow breaks in the cortex which can be called soralia with rather more justification. In both kinds of soralia the original soralial hyphae arise from infra-gonidial or medullary hyphae.

It is difficult to point to any special feature in the method of origin of the marginal soredia. When the condition is established which results in the formation of soredia, the infra-gonidial and upper medullary hyphae become active. The algal groups are closely surrounded by fungal hyphae and small single groups are separated off from the general gonidial layer and are pushed towards the margin as separate soredia. The medullary layer thus becomes very active, but no fresh cortex is formed. As a result the older cortex is thrown back and the soredia are raised to above the level of the old cortex. The actual area of cortical surface is not much reduced thereby, as the soredia are pushed up from just below the cortex without probably any cortical cells being removed. The cortex is a layer which, even near the margin, soon loses its power of growth by the formation of new cells, so that it would be of little use to an actively reproductive organ like a soredium.

The soredia of the superficial crack-like soralia originate in the same way as the circular soralia of *P. erumpens*. Once however the continuity of the cortex has been interrupted the tissue of the soral becomes very loose. The two edges of the crack now act very much in the same way as the margin of the thallus does when it gives rise to soredia. Each margin of the crack is thrown back and the active soredia-forming hyphae push up detached groups of gonidia. These hyphae run at right angles to the general direction of the medullary hyphae and parallel to the soralial edges which stand upright on the surface of the metathallus.

The soredia of the superficial soralia do not differ structurally from those of the marginal soralia. In both cases the few algal gonidia are surrounded by the fungal sheath and the extent of the air spaces is limited. The outer layers are irregular in outline, but appear at first, at any rate, to be uninterrupted by pores. The several soredia gradually move upwards and this movement is due to the growth in length of the soralial hyphae. The whole soralial tissue is much looser in *P. scutata* than in *P. erumpens*, at the same time it is possible to see that the gradual differentiation of the soredium takes place in much the same way. A small round group of gonidia, closely surrounded by hyphae, moves towards the edge of the crack of the thallus margin, becoming slightly drawn out during the process. Then as the soredium becomes more differentiated, the group of algae again becomes rounded and gradually the soredium separates from the neighbouring cells and is free to be carried away. The superficial soralia always remain narrow which is due to the facts that the underlying medullary hyphae do not grow very much in length and that the cortical cells only increase in diameter slightly.

Experiments with the germination of soredia of *P. scutata* have so far been unsuccessful but they are still in progress.

Discussion.

Reference was made to the origin of the soralia in the introductory remarks to this paper. The general impression one gains from a study of the literature is that the cortex is ruptured or broken through by pressure from within. This is the view expressed by Schwendener (17), Bitter (1, 2), Moreau (12), Rosendahl (16), myself (5), and many others; while others consider the pressure from within to be due to conditions favouring increased activity of the gonidia.

There is, however, no real tearing through of the cortex in the case described in this paper. Regular hyphae which are of infra-gonidial medullary origin make their way into this layer, and cause the cortical cells to separate without thereby creating an open wound. The true soralial tissue subsequently enters this gap in such a way that the underlying gonidia never become exposed. No portion of the cortex is destroyed. The infra-gonidial hyphae of the medulla apparently remain potentially meristematic throughout the life of the lichen. It is difficult to say to what stimulus the soral owes its origin. It can safely be stated that the stimulus affects both gonidia and fungus. That is why the result is always exactly the same. It is *not*, however, possible to say whether the stimulus causing the formation of the soralia affects the gonidia or the fungus first. There is no evidence to show that the algae play a predominant part in this process. The algae are never normally seen to get ahead of the fungus. The separation and differentiation of the soredium does not begin till the group of algae forming its gonidia has been completely surrounded by hyphae. Algae and fungus are clearly co-operating closely during the formation of the soredium.

I do not consider that moisture or drought are direct causes of soral formation. The hyphae which closely surround the gonidia have walls which act in the same way as the walls of the hyphae forming the cyphellar tissue. They will not moisten with water, so the soredia at first sight appear dry. In the soredia we have a state of the lichen in which it can pass through very dry conditions, as is usual with reproductive organs.

The production of soredia may be due to the ageing of that particular portion of the thallus. This impression might be gained from the position of the marginal soredia in those parts of the thallus of *P. scutata* which are no longer actively growing,

though this would hardly hold good for the superficial soralia of *P. erumpens*. On the other hand the formation of soredia may be due to an internal and otherwise unsatisfied reproductive stimulus ((6) p. 23), and thus bear some relation to the activity with which apothecia are formed on the same plant. I have discussed this question on former occasions (4, 5), and the views expressed by me have been criticised by Bitter ((1) p. 189 *et seq.*) and others.

Kajanus applies the term soredial branches to the isidia of *P. rufescens* (= *P. praetextata*). Reference to this is made in an earlier part of this paper. A soredium is an organ that becomes completely separated from its parent thallus. A soredial branch would therefore represent a soredium which has attached itself to its parent plant after having first become separated. That is apparently what happens in *Usnea barbata* as recorded by Schwendener ((17) pp. 137–139). It does not occur, however, in the isidia of *P. praetextata*. No separation of an isidium takes place ordinarily, but gonidial and infra-gonidial tissues grow up to form the isidium, the internal layers of which always preserve full continuity with the corresponding tissues of the parent metathallus ((7) fig. 36). The isidia of *P. praetextata* and the soredia of many lichens have in common only the fact of their endogenous origin as their subsequent development is quite different. It is still an open matter, I consider, whether the "soredial branches" of Schwendener are isidia pure and simple or not.

In this paper I am more directly concerned with showing how intimately algae and fungus work together. This intimacy is so great that any stimulus internal or external affecting one constituent of the lichen will also, if necessary, affect the other ((7) p. 754). That is why the structure of the soredium is so uniform, and it also accounts for the uniformity in the structure of the whole lichen.

It must never be forgotten that there is one great difference between the algal gonidia and the lichen fungus. The gonidia of an individual lichen may be descendants of a long line of algal ancestors which have never acted as gonidia in a lichen before. Except possibly in some of the very simplest lichens, the fungal constituent of the lichen is the descendant of a very long line of ancestors which have for untold generations lived, and which now can only exist, in partnership with algae. The lichen tradition is passed on from lichen individual to lichen individual only through the mechanism of heredity of the fungus. The algal cells will often be quite unused to the lichen partnership. Even, however, when in the soredium gonidia which are related by descent are handed down from one vegetative genera-

tion to another, they have not acquired any lichen traditions. These are transmitted by the lichen fungus only. This shows what an important part the fungus must play in lichen morphology and physiology. It does not, however, mean that the fungus is a predominant partner in the lichen consortium. Fungus and algae are as closely associated in the lichen as green and colourless tissue in the green leaf of an oak tree ((7) p. 753), and they are as dependent on one another.

The fungus has lost the power to live other than in association with the algae. Has it acquired any really new traditions? I think it can be suggested at least that it has learnt to respond immediately to any condition affecting the welfare of the gonidia. It will not grow up into a lichen without the presence of algae which stimulate it to do so.

The ascospore of the fungus reproduces on germination the fungus only. Yet the nucleus, if it is the carrier of inherited characters at all, must bring with it all the special lichen-genes. If the formation of soredia is due to some special inherited factor or set of factors, these must be transmitted from generation to generation by the ascospore or any vegetative reproductive organ of the fungus. So that it should be quite possible, should sexual reproduction take place in lichens, to produce hybrid lichens even if the algae remain the same.

In the introduction to this paper reference was made to the manner in which some authors failed to distinguish isidia from soredia. As regards function isidia are mainly assimilatory organs, that is they are vegetative organs which normally remain attached to the parent plant. The soredia are reproductive organs which are shed by their parent plants, and are of endogenous origin. Isidia may be endogenous, but they may also be exogenous; this depends really on the method of cortical growth in the particular species. An isidium may produce soredia at its tip, but this does not imply that the isidium is passing into soredia. Isidia and soredia are both distinct lichen organs.

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Summary regarding the Soredia of *P. erumpens* and *P. scutata*.

1. In *P. erumpens* and *P. scutata* the superficial soralia originate endogenously by the activity of infra-gonidial hyphae which push their way into the cortex without actually tearing a gap or making an open wound. The marginal soralia of *P. scutata* are also of endogenous origin but the soredia are pushed past the cortex of the actual margin.

2. It is impossible to say whether gonidium or fungus initiates the soral.

3. Throughout the development of the soredium fungal hyphae surround the gonidia closely. When the separation of the soredium is complete air spaces make their appearance and gradually become extensive. These are found to be in touch with the outer air by pores in the protective layer.

4. The conditions which cause the formation of soredia must directly or indirectly affect both gonidia and fungus; these therefore co-operate perfectly during the development and growth of the soredia.

5. Soredia and isidia differ from one another in that the former become completely separated from the parent metathallus while, except accidentally, the isidia remain permanently in connection with their parent plants.

6. The soredia are reproductive organs; the isidia act as assimilators.

7. Of the two lichen constituents the fungus is the lichen habitual, the gonidium the lichen casual. The fungus has learnt to interpret the wants of the algal gonidia perfectly. The gonidium has learnt nothing, yet, as a system, the lichen form of symbiosis works perfectly.

8. The infra-gonidial hyphae remain potentially meristematic throughout the life of the lichen.

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EXPLANATION OF PLATES IX AND X.

Fig. 1. *P. erumpens*. Habit of plant showing prominent veins, rhizines, and circular soralia. The material for this figure was collected by Fuehrer at Gumbinnen in August 1924. ×4.

Fig. 2. *P. erumpens*. Vertical section of well-developed soral. The cortex has been rolled back at the edges of the soral. ×50.

Fig. 3, *P. erumpens*. A group of hyphae of infra-gonidial origin have pushed their way in between the older cells of the cortex, thereby making a break in the continuity of the cortex. ×300.

Fig. 4. *P. erumpens*. Vertical section of young undifferentiated soral. On the left are seen the group of hyphae referred to in Fig. 3. On the right is seen the break in the cortex. In the centre the true soralial tissue has grown into the gap formed by the initial hyphae. The continuity of the covering layers should be noted. ×300.

Fig. 5. *P. erumpens*. Vertical section of active soralial tissue in which the gradual separation of the soredia can be followed out. Below, the roundish gonidial groups are being surrounded by hyphae. These groups gradually get drawn out as the soredia become differentiated. The upper edge shows three slight projections, the beginnings of as many soredia. Quite on the top is the lower portion of an almost free soredium. ×800.

Fig. 6. *P. erumpens*. A single soredium being pushed up by hyphae from below. There is an almost complete absence of air spaces inside. On the left is seen the edge of the cortex of the margin of the soral. ×800.

Fig. 7. *P. erumpens*. A soredium in a slightly freer condition. It is attached by only one hypha to the general soralial tissue. ×800.

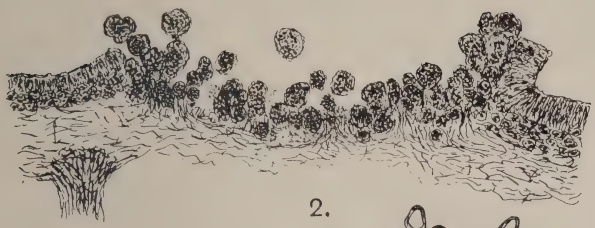
Fig. 8. *P. erumpens.* A mature quite free soredium found lying on a portion of the metathallus adjacent to a soral. The now extensive air spaces are indicated by thick lines. The intergonidial hyphae have grown, and so have the outer cells, and the gonidia. Pores are seen in section. × 800.
Fig. 9. *P. erumpens.* Pore of mature soredium seen in section. × 800.
Fig. 10. *P. erumpens.* Pore of mature soredium seen in surface view. × 800.
Fig. 11. *P. erumpens.* Two outer cells of a germinating soredium (probably belonging to *P. erumpens*) which have sent out a hypha each, which have become joined by a strut. × 800.
Fig. 12. *P. scutata.* Habit of plant showing marginal and superficial soralia. The material for this figure was collected by Dr du Rietz at Uppsala in May 1926. × 800.
Fig. 13. *P. scutata.* Vertical section of a marginal and a superficial soral. × 50.
Fig. 14. *P. scutata.* Single soredium near the edge of a superficial soral. It is being pushed up by one large hypha previous to becoming quite free from the general soralial tissue. × 800.

ON THE OCCURRENCE OF DIAPORTHE PERNICIOSA OR A CLOSELY RELATED FORM ON LILAC.

By F. C. Deighton.

In the course of an investigation at Cambridge during the last two years, of fungi occurring in the wood of lilac, a fungus hardly differing from *Diaporthe perniciosa* was very commonly isolated. It was found to be the most constant fungus isolated from the dead branches of several different bushes. Here it was generally associated with various other fungi such as *Fusarium*, but none of these was as constantly obtained as was the *Diaporthe*. Inoculation experiments were carried out on healthy lilacs with the *Diaporthe* and several of the other fungi isolated, but with no success. An account is given of some inoculations made with *Diaporthe perniciosa* and with the *Diaporthe* from lilac on peach and plum.

While on lilacs growing healthily in unshaded places no extensive die-backs occurred, it was found that on a lilac badly overshadowed by adjacent tall bushes, whole branches had died to the base, while most others were unhealthy. The appearance of some of the diseased branches was similar to that described by Miss Cayley (3) and Briton-Jones (1) for fruit trees affected with *Diaporthe perniciosa*. A slightly sunken area about an inch broad extended down one side of the branch. Behind it, the bark was dead and brown, and the wood discoloured to the centre, the discoloured portion appearing V-shaped in cross-section, very much like the photograph of *Diaporthe perniciosa* on cherry laurel in Briton-Jones's paper. The discoloured zone was always on the opposite side to a living branch, and was approximately the same breadth throughout its length.



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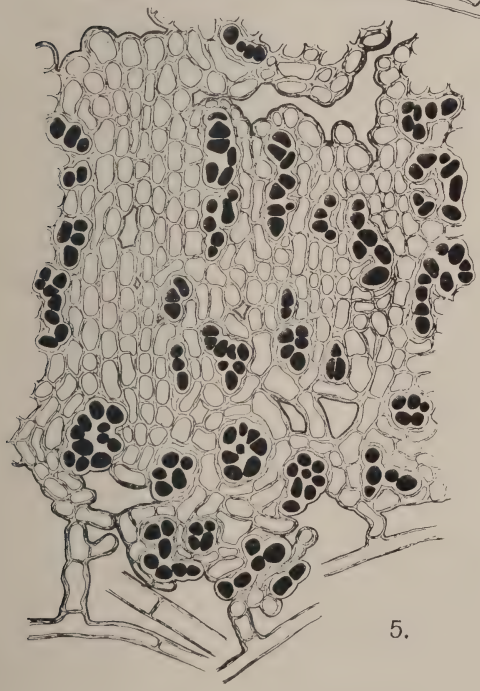

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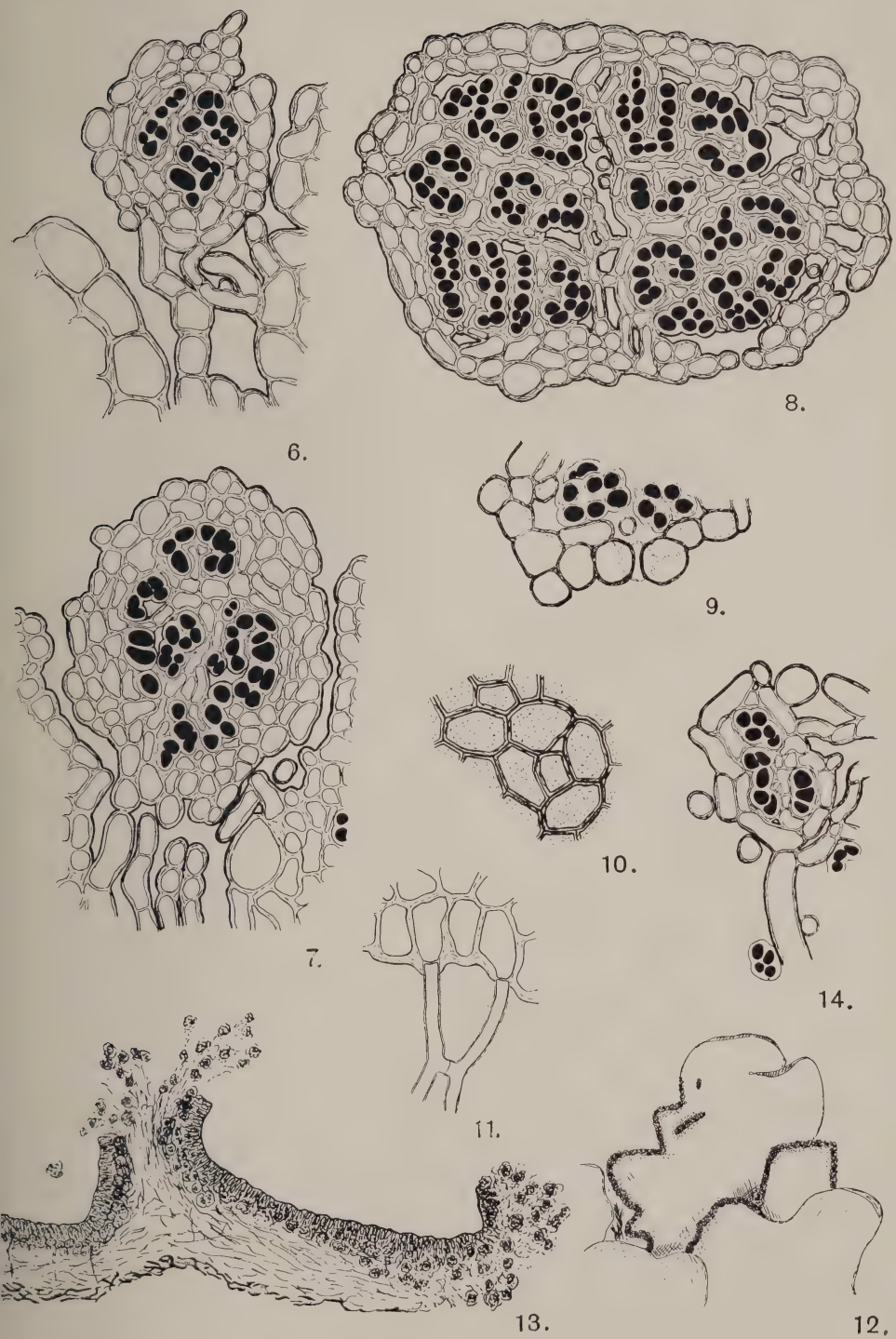
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In one branch six feet high the diseased area was not sunken, and tapered gradually towards the base, where the discoloration of the wood faded out. The bark over the faintly discoloured wood at the extreme base seemed to be healthy, though that over the more deeply discoloured wood was brown and dead. The more deeply discoloured wood contained abundant fungal hyphae, and from it *Diaporthe* and several other fungi were isolated; but in the faintly discoloured portion of the wood only a very few extremely fine hyphae could be made out. From this basal part only *Diaporthe* was isolated.

Bacteria were never encountered below the sunken areas on the lilac branches.

The fungus had evidently gained access to the wood at the extensive wounds made five years ago when the lilac bushes in this garden had been pruned hard back.

When the diseased branches were surface-sterilised and kept in a moist chamber, pycnidia or perithecia of *Diaporthe* appeared, often in a few days. As found by Miss Cayley, some strains of the fungus gave perithecia only, while others gave only pycnidia. Even in naturally infected twigs, it was found that some when kept moist produced only perithecia, while others, the majority, produced abundant pycnidia but no perithecia. Others again, produced both types of fructification.

In culture, practically no difference was observed between the lilac fungus and *Diaporthe perniciosa*, a pycnospore culture of which was kindly supplied by Miss Cayley. Ascospore cultures produced abundant perithecia with rarely a few pycnidia with undersized spores, nearly all of the "*a*" type. Pycnospore cultures, however, produced abundant pycnidia with both "*a*" spores and the filiform "*b*" spores of the same dimensions as those of *Diaporthe perniciosa*: no perithecia have been observed in these cultures.

Pycnospore cultures of the lilac *Diaporthe* regularly gave a grey coloration to the medium when grown on various substrata, a coloration which was not given by *Diaporthe perniciosa*. This was the only difference that could be observed between the two fungi. It is therefore concluded that the fungus, if not identical with *Diaporthe perniciosa*, is a very closely related form.

Inoculation Experiments.

(*a*) *On Lilac and Privet.*

March, 1925. Nine inoculations were made on lilac and five on privet (*Ligustrum vulgare*) with the lilac *Diaporthe*. T-shaped incisions were made and the bark turned back to expose the wood. The mycelium of the fungus was then inserted and the whole bound round with wool.

July, 1925. Six inoculations were made on lilac with the mycelium of the lilac *Diaporthe* in T-cuts.

July, 1925. Inoculations were made with *Diaporthe perniciosa*, three in T-cuts on lilac, using in two cases a pycnospore suspension and in the third case mycelium. Two inoculations were made on cut ends of twigs of lilac, and three on cut ends of privet twigs, with a pycnospore suspension.

These inoculations were made on twigs of one to three years old. None were successful.

(*b*) *On Peach growing in a Greenhouse.*

March 2nd, 1926. Seventeen inoculations were made with a heavy pycnospore suspension of the lilac *Diaporthe*; eleven on cut ends of twigs and six in T-cuts. The twigs used were one and two years old. No inoculations were successful. In all cases investigated of the inoculations on cut ends, a large quantity of gum was found within six weeks in the vessels below the cut surface, completely limiting the growth of the fungus. In the T-cuts examined the fungus had penetrated as far as the oldest vessels, but gum was present all round the inoculated part in large quantity and probably formed a barrier to further growth of the fungus. This barrier was similar in kind to the "gum barriers" described by Brooks and Moore (2) in unsuccessful invasions of woody tissues by *Stereum purpureum*.

February 24th, 1926. Nineteen inoculations were made with a pycnospore suspension of *Diaporthe perniciosa*. Eleven were on cut ends of twigs and four in T-cuts. None were successful.

(*c*) *On Plum growing in a Greenhouse.*

In November, 1925, inoculations were made with *Diaporthe perniciosa* on greenhouse plums by Mr F. S. Ward. Six were mycelium inoculations in T-cuts and six were pycnospore inoculations on cut extremities. Twigs of various ages were inoculated. There were no positive infections. By March, 1926, there was in all cases examined a large quantity of gum in the vessels below the fungal hyphae.

On February 24th, 1926, inoculations were made with pycnospores of *Diaporthe perniciosa*, seven in T-cuts and eight on cut extremities of twigs. The twigs used were generally one year old, occasionally two years old. No inoculations were successful. In all cases, investigated two months later, large quantities of gum were present in the vessels below the wound, and no fungus was present below the gum layer.

On March 2nd, 1926, inoculations were made with pycnospores of the lilac *Diaporthe*, three in T-cuts and nine on cut extremities of twigs one and two years old. No inoculations were successful.

In order to confirm Miss Cayley's results (3), inoculations were made in June on current year's growth of peach and plum in a greenhouse, using *Diaporthe perniciosa* and the lilac *Diaporthe*. Pycnospores in water suspension were introduced into T-cuts. None of these inoculations were successful, the growth of the fungus being limited by the rapid formation of "gum barriers."

Conclusion.

In the absence of any positive infections, the evidence for the parasitism of *Diaporthe* on lilac is as unsatisfactory as often is the case in fruit trees. From the evidence given above, however, it seems extremely likely that under unfavourable conditions for the lilac, such as dense shade, *Diaporthe* can attack the wood —at least that part which is not actively functioning. The branch is attacked on the side where no large living branches occur.

It is possible that some other fungi such as *Fusarium* may help in the attack on lilac, but the evidence for this is insufficient. In most cases investigated, the other fungi were clearly secondary whatever the *Diaporthe* may have been.

No extensive work was carried out on wound gum formation in lilac, but it was found to follow in the main the course in plum and peach as described by Swarbrick (4) and Brooks and Moore (2). The gum, however, is formed much slower and never causes so extensive a blocking of the vessels as in those plants. It seems probable that unfavourable conditions such as shade retard gum formation sufficiently for the attacking fungus to get through. Thus successive "gum barriers" may be started but may never be completed before the fungus reaches them. In this case there may be an extensive die-back. This seems to be the condition of the lilac branch described.

In conclusion I wish to express my thanks to Mr F. T. Brooks for the instigation of this work and for his assistance.

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REVIEWS.

A Monograph of Lichens found in Britain, Part II. 2nd edition, revised. By A. LORRAIN SMITH, F.L.S. pp. ix, 447. 63 plates. £1.

In the first edition of Part I of this monograph (1894) Crombie followed Nylander in his classification of Lichens. This method was to a considerable extent departed from in the first edition of Part II. In the second edition of Part I a change was again made by Miss Lorrain Smith, and a more recent classification following that of Zahlbruckner was used. In an Appendix to Part I this method was extended to the Lichens described in Part II. The new classification was used in the *Handbook of British Lichens,* 1921. We have now in these two parts of the monograph the British Lichens arranged according to the more recent methods.

In this edition there are several alterations: the genus *Gyalecta* is removed from the Lecideaceae and placed in the family Gyalectaceae, and this genus now includes the species *lutea* and *diluta* formerly placed in the genus *Biatorina.* As before the large genus *Lecidea* is divided into four sections: *Psora, Biatora, Eulecidea* and *Mycoblastus.* Following the method given in the handbook, the section *Eulecidea* is divided into two groups according to the colour of the hypothecium. Further the genera *Biatorina, Bilimbia* and *Bacidia* are divided into groups according to the colour of the apothecia. In the Pyrenulaceae an additional genus *Clathroporina* with two species follows the genus *Porina.*

In this new edition there are several alterations of specific names: *Lecidea ochracea* Wedd. is now included under *L. fuscorubens* Nyl., and *Lecidea pleiospora* A. L. Sm. is now *L. geophana* Nyl. And instead of *Verrucaria calciseda* DC. and *Thelidium incavatum* Mudd, we now have *V. sphinctrina* Nyl. and *T. Auruntii* Krempelh. Many of Dr Stirton's species still remain, though after an examination of his herbarium several have been dropped.

In an Appendix a new arrangement of the genus *Acarospora* is given as the result of an examination by Dr Magnusson of the specimens in the British Museum. And there is a list of new species of the genus *Crocynia* from a monograph on this genus by Hue and B. de Lesdain. H. H. K.

A Monograph of the Mycetozoa. By ARTHUR LISTER. Third edition, revised by GULIELMA LISTER. British Museum (Natural History). pp. xxxii, 296. With 223 plates (64 coloured) and 56 text-figs. £1. 1*s.* 6*d.*

The third edition of this monograph will be welcomed by all students of Mycetozoa. It marks a distinct advance upon the previous edition and is a worthy tribute to the combination of scientific and artistic ability of Miss Lister who has for the second time revised her father's work. When one scans the first edition published in 1894 and compares it with the present, it is surely a matter for congratulation that the study of the Mycetozoa has reached such proportions, as testified by the amount of material which has come to hand from so many and widespread localities, that such a revision is necessary.

The introduction has been carefully revised and the account of the life-history of the group brought up-to-date by the inclusion of fresh matter from the historical side and also from the biological standpoint. The reference to the work of Pinoy, and also the researches of Skupienski confirming and extending Jahn's work, and the addition of drawings made from Jahn's stained preparations will prove very helpful to the student interested in the biology of the group. With reference to the mitotic division of the nuclei in the growing plasmodium mentioned as a footnote on pp. xii and xiii, many observations made by the reviewer upon both smears and stained spreading fans of the plasmodium of *Badhamia utricularis* have always produced a negative result: there is evidently room for further research in this direction.

The inclusion of the method of collecting and mounting material should be of considerable assistance to would-be students of the Mycetozoa and forms a fitting conclusion to the introduction.

The text has undergone thorough revision and has been brought up-to-date; descriptions of three new genera have been included as well as those of forty-six additional species some of which, given as varieties in the previous edition, have been judiciously raised to specific rank. Nomenclature has occasionally been altered in conformity with the International Rules.

Twenty-two new plates have been added, eight of these being in colour from water-colour drawings made by Miss Lister. It is, however, the opinion of the writer, that several of the plates are not so well reproduced as in the second edition, e.g. *Diderma radiatum*; the difference is most noticeable in some of the black and white plates, e.g. Plates 149 and 150 and also those of *Cribraria intricata*, *C. tenella*, and *C. pyriformis*, which are very weak in tone, possibly due to the quality of the paper being inferior to that of the second edition.

Apart from these details, the new edition of this classical monograph with its extensive bibliography, the systematic side of which has been wisely separated from that dealing with the introduction, is a much needed and valuable contribution to the knowledge of the Mycetozoa, and is a testimony to the enthusiasm of Miss Lister, and a lasting tribute to her father who did so much pioneer work in attracting attention to the study of this most interesting group of organisms. H. J. H.

The Aspergilli. By CHARLES THOM and MARGARET B. CHURCH. pp. ix, 272, tt. iv, text-figs. 6″ × 9″. London: Baillière, Tindall and Cox; Baltimore: Williams and Wilkins. 22*s.* 6*d.*

Doubtless at the present time any monograph on the genus *Aspergillus* would attract many mycologists, but the names of the authors of the work here noticed are certain to ensure for it an extensive sale. Professor Thom of the Bureau of Chemistry, United States Department of Agriculture and his assistant Miss Church by their investigation of the fungi occurring on mouldy foodstuffs and such like have established a reputation which enables them to speak with authority on the complicated taxonomy of several intricate genera of which *Aspergillus* and *Penicillium* (a monograph of which is in preparation) are well-known examples. Everyone who has attempted to identify species of *Aspergillus* knows the difficulties that are encountered. It would be going too far to say that the present monograph makes the naming of a species easy but there is so much information packed into it that one is aware of the possibilities and therefore less likely to stray.

The book is divided into two main sections. The first of these deals with matters of general biological interest—culture, physiological and biochemical characters, fermentative activities and their uses in industry; and the part played by several species in human and animal disease. Incidentally such genera as *Sterigmatocystis*, *Diplostephanus*, *Aspergilliopsis* Speg. (= *Rhopalocystis* Grove) and *Aspergilliopsis* Sopp are not upheld: the authors, moreover, do not use the name *Eurotium* for the perfect form.

The second part of the book is concerned with taxonomy. Eleven main groups are established. These "collective species" have a characteristic range of colony-colour though in some this varies with age. These are fully described from all points of view: the species which have been seen by the authors are given with morphological and historical detail while those which are regarded as synonyms or doubtful are commented upon more or less fully. The stability of the species in culture is described, how some remain constant while others saltate. There are three keys: two brief ones, of which the first is based on colour of heads and stalks, and the second a synopsis of the third detailed key which is based on general characters.

The first impression gained on dipping into the work is that it is sketchy, as if the authors had written a fair copy of their notes without any subsequent polishing. This is regrettable as it is certainly by far the most complete treatment of the genus that we have.

There are many matters which might occasion comment—and a reviewer would not be human who commented favourably on them all—but the only purpose here is to indicate the importance of the volume which everyone interested in moulds, from no matter what point of view, will need to possess.

J. R.

Die Pilze Mitteleuropas. Band 1. Die Rohrlinge (Boletaceae). By FRANZ KALLENBACH. Leipzig: Dr Werner Klinkhardt, 1926. 4 marks each Lieferung.

Under the general editorship of Professors H. Kniep, P. Claussen and J. Bass, three German scientific societies are publishing an atlas of the higher fungi of Central Europe. As is well known the late Adalbert Ricken, author of the important *Die Blätterpilze* (Agaricaceae) intended to complete his work with the consideration of the other Basidiomycetes. After his death in 1921 the Deutschen Gesellschaft für Pilzkunde took up the idea and apportioned the work to various specialists. The scheme of publication is to issue every two or three months four plates, of which two are coloured, together with the appropriate text. Two fascicles are now to hand. Plate 1 shows *Boletus satanus* (ten drawings), and Plate 2 this species with *Boletus rhodoxanthus*, *B. erythropus*, *B. luridus*, and *B. miniatoporus* (six drawings). The plates are 13½″ × 10″. The two black and white plates of the first fascicle (numbered 10 and 11) give fourteen photographs and one anatomical drawing. The text of four pages is devoted to a very full account of *B. satanus*: summary of original diagnosis, extended description, edible qualities, distinguishing characters, microscopic characters, habitat, distribution, history, literature and short diagnosis. The second fascicle has two coloured plates only, the first with eleven figures of *rhodoxanthus*, the second with the same number of *B. impolitus*· the text has not yet been issued. The next plates (nos. 5–9) are to show *B. pseudo-sulphureus* Kallenb., *B. pulverulentus*, *B. rimosus*, *B. erythropus*, and *B. regius*. The plates are very good of their type but heavily loaded paper printed in the three-colour process is never very pleasing. They are incomparably better than those in Ricken's work which are often said to have been badly printed on account of war conditions—but publication began in 1910 and was more than two-thirds through in Aug. 1914.

The value of the present Icones will be in the number of figures devoted to one species giving stages of development of different examples in a manner recalling Barla's *Les Champignons des Alpes-maritimes*. It is a matter of congratulation that owing to the original scheme of continuing Ricken's work the beginning is made with *Boletus* and not *Amanita*. So that even if unfortunately it should turn out that for some reason publication has to be discontinued, mycologists will have drawings of some species not previously well done. If the scheme is carried out in full (e.g. twenty fascicles for the Boletaceae alone) the Atlas will be the most complete in existence. The price is to be raised to five marks after the issue of the third fascicle. The British Mycological Society wish the German Mycological Society every success in their heavy undertaking.

J. R.

PROCEEDINGS, 1926.

MEETING, UNIVERSITY COLLEGE, LONDON. *23rd January.*

B. Barnes. Preliminary observations on the Physiology of *Lachnea.*

A. Chaston Chapman. A Plea for a National Institute of Industrial Micro-Biology.

Kodak, Ltd. The Eastman Colorimeter.

J. Ramsbottom. Fragmenta Mycologica V.

G. Tandy. Cytology of *Pyronema domesticum* Sacc.

W. M. Ware. *Pseudoperonospora Humuli* Miyabe and Tak., and its mycelial invasion of the Host Plant.

MEETING, LISTER INSTITUTE, LONDON. *20th March.*

SPRING FORAY, ARUNDEL. *21st–25th May.*

PHYTOPATHOLOGICAL MEETING, HARPENDEN. *3rd July.*

AUTUMN FORAY AND ANNUAL MEETING, HEREFORD. *27th September–2nd October.*

FORAY WITH BRITISH ECOLOGICAL SOCIETY, BOX HILL. *9th October.*

FORAY WITH ESSEX FIELD CLUB, EPPING FOREST. *16th October.*

AUTUMN FORAY FOR LONDON STUDENTS, VIRGINIA WATER. *23rd October.*

MEETING, UNIVERSITY COLLEGE, LONDON. *20th November.*

W. R. Ivimey Cook. The genus *Ligniera.*

Prof. O. V. Darbishire. Isidia and soredia of the lichen *Peltigera.*

W. J. Dowson. An extraordinary *Botrytis* causing a disease of *Narcissus* leaves.

W. A. Roach. On the nature of disease resistance in plants, with special reference to Wart Disease of Potatoes.

A. L. Smith. A new family of Lichens.

THE BRITISH MYCOLOGICAL SOCIETY was founded in 1896 for "the study of Mycology in all its branches." In its earlier years the Society was carried on much as had been the mycological section of the Woolhope Club, but differed mainly in holding the annual meeting and foray in various parts of the country and in having a journal wholly devoted to Mycology. In the year 1909 an informal spring foray was added to the Society's activities. Since 1921 a much fuller programme has been carried out; the number of forays has been increased while indoor meetings provide for the report and discussion of the results of investigations. Mycologists visiting England are cordially invited to attend any of the meetings of the Society. The programme for the year is issued in January and may be obtained from any of the officers.

The Transactions of the Society appeared annually until 1919 when two numbers were issued; they are now published quarterly. The Transactions deal with every branch of Mycology, and a volume at present contains at least 240 pages with numerous plates and text-figures. Owing to the increase in membership of the Society and the sales of the Transactions, arrangements were made in 1922 for the Cambridge University Press to take over the publication. The annual subscription for Membership of the Society is £1, payable in advance and is due on January 1st of each year. Members are entitled to receive the Transactions of the Society during the year covered by their subscription. For the subscription price to non-members see overleaf.

Many of the earlier numbers of the Transactions are now out of print, but occasionally copies of these come to hand. Information as to parts available can be obtained on application to the General Secretary.

Papers submitted for publication should be in a condition suitable for press. The Editors are willing to give advice and assistance in the preparation of MSS. Illustrations should be kept down to a minimum. Members are asked to help the Editors to bring the Transactions out regularly. Fifty reprints are provided free of charge: additional reprints may be obtained through the Cambridge University Press.

Attention of members is called to the advisability of sending cultures of fungi to the NATIONAL COLLECTION OF TYPE CULTURES, Lister Institute, Chelsea Gardens, S.W. 7, for preservation and distribution.

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HEREFORD FORAY, 1927

Photo. Col. C. T. Green

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THE HEREFORD FORAY.

By E. M. Wakefield.

Sept. 27th to Oct. 2nd, 1926.

THE thirtieth Autumn Fungus Foray and Annual General Meeting was held at Hereford from September 27th to October 2nd, about fifty members being present. As headquarters for meetings the Woolhope Club Room at the Public Library was available, and space for the exhibition of specimens was provided in the Museum in the same building.

On the Monday evening, Col. M. J. G. Scobie, the President of the Woolhope Club, extended to the Society an official welcome to Hereford, referring to the historical connection between the two Societies. Dr Pethybridge replied on behalf of the Society. Following upon this pleasant formality the Annual General Meeting was held. Dr E. J. Butler was elected President for 1927, with Miss A. Lorrain Smith as second Vice-President. Messrs H. H. Knight and E. W. Mason were elected to the Council. It was decided that the Autumn Foray in 1927 should be held in Scotland, the details to be arranged in conjunction with the Scottish Cryptogamic Society.

On Tuesday, collecting began with a whole day's excursion to Wormesley and Credenhill. *Cheilymenia dalmeniensis* and *Androsaceus Hudsonii* were secured soon after entering the grounds of Wormesley Grange, and *Ganoderma resinaceum* was also collected there. At Credenhill were found amongst numerous other species *Russula lilacea, Inocybe pyriodora, I. conformata, I. corydalina, Cortinarius purpurascens,* and *Eichleriella spinulosa.* In the evening Dr Pethybridge delivered his Presidential address, on "Mycology and Plant Pathology." The meeting was held, by kind invitation of Miss Bull, in the rooms at her house where the Woolhope Club used to meet when Dr Bull was one of its leading spirits.

On the Wednesday, the woods on Dinmore Hill were visited. The woods have unfortunately been much cut, and the ground proved to be rather poor in Agarics, but on the north side numerous resupinate Hymenomycetes were found, including *Corticium byssinum* and *Tomentellina ferruginosa,* both of which are new to Britain. The trees were mostly oak and sweet chestnut, and on rotten fallen branches *Femsjonia luteoalba* was particularly abundant. Mr Ashby picked up a *Hypoxylon* which was later identified by Mr E. W. Mason as the rare *Hypoxylon argillaceum.* Other species found on this day were *Leptopodia*

ephippium, *Poria cupora*, *P. purpurea* and *Corticium atrovirens*, and Dr Bayliss Elliott reported later *Ctenomyces serratus*, *Hypocrea gelatinosa*, and *Rosellinia mammoidea*.

After the return to Hereford the party paid a visit to the cider works of Messrs Bulmer, and were shown over the factory by the Mayor of Hereford and Dr Durham (chemist to the firm). In the evening Mr Ramsbottom gave a public lecture on the larger fungi, illustrated by coloured lantern slides.

Thursday's excursion was to Moccas Old Park, which proved ideal hunting-ground. The park is remarkable for its fine old trees, and the many fallen, undisturbed trunks provided ample occupation for mycologists. The ground proved very rich in Clavarias, in spite of a rather dense undergrowth of bracken. *Clavaria Kunzii* and its dwarf form *C. Krombholzii* were abundant. *C. amethystina*, *C. tenuipes*, and *C. gigaspora* were also secured, the latter being only the second record of this species. Hygrophori were also abundant: *Hygrophorus intermedius*, *H. Reai*, *H. calyptraeformis*, and a new species, *H. lepidopus*, were found in addition to the more common species.

In the evening the Society was entertained at dinner by the Woolhope Club at the Green Dragon Hotel, the occasion being a celebration of the seventy-fifth anniversary of the Club.

On the Friday, Haugh Wood, Mordiford, and the grounds at Holme Lacy were visited, but neither locality was very productive. *Lactarius vellereus* was remarkable for its abundance at Holme Lacy. Other finds were *Lactarius controversus*, *Omphalia atropuncta*, *Boletus nigrescens*, *Ganoderma lucidum*, *Corticium fastidiosum*, and *Kuehneola albida*. The day finished with a pleasant visit to Dr Durham's house, where tea was provided.

In the evening the President exhibited a new potato tuber rot due to *Rosellinia necatrix*, and mentioned that the same fungus has been found attacking narcissus bulbs in the Scilly Isles.

Mr Carleton Rea commented on the finds of the week.

The meeting concluded with votes of thanks to the Woolhope Club and in particular to Dr Durham and Miss Bull; and to the various landowners who had given permission for their ground to be worked.

The subjoined list of species collected is the result of the work of many members. In particular the writer is specially indebted to Mr Rea, Mr Ramsbottom, Mr Pearson, Mr Buddin, and Dr Bayliss Elliott.

Species marked as being collected at Hereford were obtained from Dr Durham's garden. Those from Ross were brought in by Mr F. A. Mason on the first day of the meeting. Species marked with an asterisk are new to Britain.

Complete List of Species collected during the Foray.

C. = Credenhill; *D.* = Dinmore; *H.* = Haugh Wood; *L.* = Holme Lacy; *M.* = Moccas Old Park; *W.* = Wormesley.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr., *C.*, *D.*, *H.*, pantherina (DC.) Fr., *D.*, rubescens (Pers.) Fr., *M.*

Amanitopsis vaginata (Bull.) Roze, *L.*, fulva (Schaeff.) W. G. Sm., *D.*, *M.*

Lepiota rhacodes (Vitt.) Fr., *W.*, constricta (Fr.) Quél., *M.*, amianthina (Scop.) Fr., *M.*

Armillaria mellea (Vahl) Fr., *C.* (rhizomorphs only), *W.*, *H.*, mucida (Schrad.) Fr., *M.*

Tricholoma sejunctum (Sow.) Fr., *D.*, resplendens Fr., *D.*, fulvum (DC.) Fr., *C.*, albobrunneum (Pers.) Fr., *W.*, rutilans (Schaeff.) Fr., *C.*, argyraceum (Bull.) Fr., *M.*, cuneifolium Fr., *M.*, *H.*, *L.*, saponaceum Fr., *D.*, carneum (Bull.) Fr., *W.*, acerbum (Bull.) Fr., *D.*, cinerascens (Bull. non Fr.) Quél., *W.*

Russula chloroides (Krombh.) Bres., *W.*, *D.*, nigricans (Bull.) Fr., *W.*, *D.*, *M.*, adusta (Pers.) Fr., *D.*, incarnata Quél., *W.*, virescens (Schaeff.) Fr., *M.*, lepida Fr., *C.*, *D.*, *M.*, cyanoxantha (Schaeff.) Fr., *C.*, *D.*, *M.*, lilacea Quél., *C.*, foetens (Pers.) Fr., *L.*, ochroleuca (Pers.) Fr., *C.*, fellea Fr., *C.*, rosacea (Pers.) Fr., *M.*, fragilis (Pers.) Fr., *W.*, *D.*, *M.*, and var. fallax (Schaeff.) Massee, *L.*, emetica (Schaeff.) Fr., *D.*, atropurpurea (Krombh.) Maire, *W.*, *D.*, *H.*, xerampelina (Schaeff.) Fr., *M.*, *L.*, puellaris Fr., *W.*, punctata (Gill.) Maire, *M.*

Mycena pelianthina Fr., *M.*, pura (Pers.) Fr., *C.*, *M.*, flavo-alba Fr., *M.*, rugosa Fr., *C.*, *D.*, galericulata (Scop.) Fr., *D.*, *H.*, *L.*, polygramma (Bull.) Fr., *D.*, *M.*, *H.*, ammoniaca Fr., *M.*, *L.*, metata Fr., *M.*, vitilis Fr., *W.*, *M.*, acicula (Schaeff.) Fr., *D.*, haematopus (Pers.) Fr., *M.*, sanguinolenta (A. & S.) Fr., *W.*, *D.*, galopus (Pers.) Fr., *W.*, *D.*, *L.*, stylobates (Pers.) Fr., *W.*, *D.*

Collybia radicata (Relh.) Berk., *C.*, *H.*, platyphylla (Pers.) Fr., *W.*, fusipes (Bull.) Berk., *C.*, *D.*, *L.*, and var. oedematopus (Schaeff.) Fr., *W.*, maculata (A. & S.) Fr., *D.*, velutipes (Curt.) Fr., *C.*, tuberosa (Bull.) Fr., *D.*

Marasmius peronatus (Bolt.) Fr., *C.*, *D.*, erythropus (Pers.) Fr., *W.*, *C.*, *M.*, hariolorum (DC.) Quél., *C.*, dryophilus (Bull.) Karst., *W.*, *C.*, *D.*, *M.*, *L.*, *H.*, and var. aquosus (Bull.) Rea, *W.*, *C.*, foetidus (Sow.) Fr., *C.*, ramealis (Bull.) Fr., *W.*, *C.*, *D.*, *H.*

Androsaceus rotula (Scop.) Pat., *M.*, *W.*, Hudsonii (Pers.) Pat., *W.*

Lactarius torminosus (Schaeff.) Fr., *W.*, *D.*, turpis (Weinm.) Fr., *D.*, controversus (Pers.) Fr., *L.*, pubescens Fr., *W.*, blennius Fr., *M.*, pyrogalus (Bull.) Fr., *M.*, *L.*, chrysorheus Fr., *D.*, piperatus (Scop.) Fr., *D.*, vellereus Fr., *W.*, *C.*, *D.*, *H.*, *L.*, quietus Fr., *W.*, *D.*, *M.*, vietus Fr., *W.*, rufus (Scop.) Fr., *D.*, glyciosmus Fr., *W.*, fuliginosus Fr., *D.*, serifluus (DC.) Fr., *M.*, mitissimus Fr., *C.*, subdulcis (Pers.) Fr., *D.*, *M.*

Hygrophorus eburneus (Bull.) Fr., *Ross*, cossus (Sow.) Fr., *H.*, pratensis (Pers.) Fr., *W.*, *M.*, virgineus (Wulf.) Fr., *M.*, *L.*, niveus (Scop.) Fr., *C.*, *M.*, clivalis Fr., *M.*, ovinus (Bull.) Fr., *L.*, *lepidopus Rea, *M.*, laetus (Pers.) Fr., *M.*, coccineus (Schaeff.) Fr., *M.*, Reai Maire, *M.*, turundus Fr., *M.*, puniceus Fr., *M.*, intermedius Pass., *M.*, conicus (Scop.) Fr., *M.*, calyptraeformis Berk., *W.*, chlorophanus Fr., *W.*, *M.*, psittacinus (Schaeff.) Fr., *W.*, *D.*, *M.*, unguinosus Fr., *M.*

Clitocybe clavipes (Pers.) Fr., *M.*, aurantiaca (Wulf.) Studer, *W.*, *M.*, odora (Bull.) Fr., *C.*, *D.*, dealbata (Sow.) Fr., *D.*, *H.*, *M.*, infundibuliformis (Schaeff.) Fr., *W.*, *D.*, *M.*, *L.*, and var. membranacea (Fl. Dan.) Fr., *W.*, incilis Fr., *M.*, flaccida (Sow.) Fr., *W.*, fragrans (Sow.) Fr., *W.*

Laccaria laccata (Scop.) Berk. & Br., *W.*, *D.*, *M.*, and var. amethystina (Vaill.) Berk. & Br., *C.*

Omphalia rustica Fr., *M.*, atropuncta (Pers.) Quél., *H.*, fibula (Bull.) Fr., *M.*, and var. Swartzii Fr., *M.*

Pleurotus sapidus Schulz., *W.*, acerosus Fr., *M.*, applicatus (Batsch) Berk., *M.*

Cantharellus cibarius Fr., *W.*, *D.*, cinereus (Pers.) Fr., *H.*
Craterellus cornucopioides (Linn.) Fr., *D.*
Dictyolus muscigenus (Bull.) Quél., *D.*
Lentinus cochleatus (Pers.) Fr., *W.*, *M.*
Panus torulosus (Pers.) Fr., *W.*, *C.*, stipticus (Bull.) Fr., *W.*, *H.*
Pluteus cervinus (Schaeff.) Fr., *W.*, *D.*, salicinus (Pers.) Fr., *D.*, *M.*, nanus (Pers.) Fr., *M.*, and var. lutescens Fr., *M.*
Entoloma sinuatum Fr., *M.*, lividum (Bull.) Fr., *D.*, *L.*, jubatum Fr., *D.*, *M.*, sericeum (Bull.) Fr., *M.*, *L.*, nidorosum Fr., *D.*, *M.*
Nolanea pascua (Pers.) Fr., *M.*, papillata Bres., *M.*
Clitopilus prunulus (Scop.) Fr., *D.*, *H.*
Claudopus variabilis (Pers.) W. G. Sm., *M.*
Paxillus involutus (Batsch) Fr., *W.*, *D.*, *L.*
Pholiota erebia Fr., *M.*, radicosa (Bull.) Fr., *D.*, squarrosa (Müll.) Fr., *M.*, spectabilis Fr., *D.*, *M.*, mutabilis (Schaeff.) Fr., *D.*, *M.*, marginata (Batsch) Fr., *W.*, *M.*
Bolbitius titubans (Bull.) Fr., *L.*
Inocybe pyriodora (Pers.) Fr., *C.*, *Ross*, rimosa (Bull.) Fr., *M.*, *L.*, corydalina Quél., *C.*, geophylla (Sow.) Fr., *W.*, *M.*, *L.*, and var. lilacina Fr., *C.*, *M.*, conformata Karst., *C.*, cincinnata Fr., *M.*
Astrosporina asterospora (Quél.) Rea, *M.*, *L.*, petiginosa (Fr.) Rea, *D.*
Hebeloma fastibile Fr., *W.*, crustuliniforme (Bull.) Fr., *D.*, *M.*, *H.*, *L.*, longicaudum (Pers.) Fr., *L.*
Naucoria escharoides Fr., *W.*
Galera tenera (Schaeff.) Fr., *M.*, *H.*, *L.*, hypnorum (Schrank) Fr., *D.*, *M.*
Tubaria furfuracea (Pers.) W. G. Sm., *W.*, *D.*, *M.*, *H.*, inquilina (Fr.) W. G. Sm., *W.*, *D.*
Flammula sapinea Fr., *C.*, *L.*, ochrochlora Fr., *W.*, *D.*, *H.*, gummosa (Lasch) Fr., *C.*
Cortinarius (Phlegmacium) largus Fr., *D.*, purpurascens Fr., *C.*
Cortinarius (Myxacium) arvinaceus Fr., *C.*, elatior Fr., *W.*, *C.*, *D.*
Cortinarius (Dermocybe) tabularis (Bull.) Fr., *W.*, caninus Fr., *H.*, lepidopus Cooke, *W.*
Cortinarius (Telamonia) torvus Fr., *D.*, armillatus Fr., *D.*, hinnuleus (Sow.) Fr., *M.*, *L.*, brunneus (Pers.) Fr., *L.*, incisus (Pers.) Fr., *D.*, paleaceus (Weinm.) Fr., *D.*
Cortinarius (Hydrocybe) duracinus Fr., *W.*
Crepidotus mollis (Schaeff.) Fr., *W.*, *M.*
Psaliota arvensis (Schaeff.) Fr., *C.*, campestris (Linn.) Fr., *H.*, villatica (Brond.) Magn., *W.*, haemorrhoidaria Kalchbr., *M.*, comtula Fr., *M.*
Stropharia aeruginosa (Curt.) Fr., *W.*, *D.*
Anellaria separata (Linn.) Karst., *W.*, *M.*
Gomphidius viscidus (Linn.) Fr., *W.*
Hypholoma sublateritium (Schaeff.) Fr., *D.*, *H.*, capnoides Fr., *C.*, fasciculare (Huds.) Fr., *W.*, *C.*, *D.*, *M.*, *H.*, *L.*, pyrotrichum (Holmsk.) Fr., *Ross*, *C.*, *M.*, velutinum (Pers.) Fr., *W.*, *L.*, appendiculatum (Bull.) Fr., *D.*
Panaeolus sphinctrinus Fr., *W.*, campanulatus (Linn.) Fr., *M.*
Psathyrella disseminata (Pers.) Fr., *C.*
Psilocybe ericaea (Pers.) Fr., *M.*, uda (Pers.) Fr., *W.*, semilanceata Fr , *W.*, *M.*, *L.*
Coprinus atramentarius (Bull.) Fr., *W.*, *Ross*, niveus (Pers.) Fr., *M.*, *H.*, *L.*, plicatilis (Curt.) Fr., *W.*, *M.*, *H.*
Boletus luteus (Linn.) Fr., *D.*, elegans (Schum.) Fr., *W.*, *L.*, chrysenteron (Bull.) Fr., *W.*, *C.*, *D.*, *L.*, subtomentosus (Linn.) Fr., *W.*, *C.*, *M.*, *L.*, versicolor Rostk., *M.*, edulis (Bull.) Fr., *D.*, reticulatus (Schaeff.) Boud., *M.*, impolitus Fr., *D.*, pachypus Fr., *W.*, luridus (Schaeff.) Fr., *D.*, *W.*, erythropus (Pers.) Quél., *W.*, *D.*, purpureus Fr., *W.*, versipellis Fr., *D.*, scaber (Bull.) Fr., *W.*, *D.*, nigrescens Roze & Rich., *D.*, *H.*
Strobilomyces strobilaceus (Scop.) Berk., *D.*
Polyporus nummularius (Bull.) Quél., *W.*, picipes Fr., *L.*, squamosus (Huds.) Fr., *D.*, *M.*, intybaceus Fr., *W.*, sulphureus (Bull.) Fr., *W.*, *M.*, *L.*, giganteus (Pers.) Fr., *C.*, *W.*, *M.*, betulinus (Bull.) Fr., *C.*, *D.*, *M.*, *L.*, dryadeus (Pers.) Fr., *W.*, *D.*, *H.*, hispidus (Bull.) Fr., *H.*, amorphus Fr., *C.*, *M.*,

adustus (Willd.) Fr., *W.*, *C.*, *D.*, fragilis Fr., *D.*, caesius (Schrad.) Fr., *W.*, *D.*, stipticus (Pers.) Fr., *W.*, *M.*
Fomes ferruginosus (Schrad.) Massee, *M.*, ulmarius (Sow.) Fr., *W.*, *M.* on *Aesculus Hippocastanum*, *L.*, annosus Fr., *C.*, *H.*, connatus Fr., *W.*
Ganoderma lucidum (Leyss.) Karst., *H.*, applanatum (Pers.) Pat., *M.*, *L.*, *Ross*, resinaceum Boud., *W.*, *L.*
Poria eupora Karst., *D.*, hymenocystis Berk. & Br., *D.*, *M.*, purpurea Fr., *D.*
Polystictus hirsutus (Wulf.) Fr., *M.*, versicolor (Linn.) Fr., *W.*, *D.*, *M.*, *L.*
Irpex obliquus (Schrad.) Fr., *W.*, *D.*, *M.*, *H.*
Lenzites betulina (Linn.) Fr., *W.*, *D.*
Trametes gibbosa (Pers.) Fr., *C.*, mollis (Sommerf.) Fr., *M.*
Daedalea biennis (Bull.) Quél., *C.*, *D.*, *M.*, *H.*
Merulius tremellosus (Schrad.) Fr., *W.*, *M.*
Phlebia merismoides Fr., *D.*
Fistulina hepatica (Huds.) Fr., *C.*, *D.*, *M.*, *H.*, *L.*
Hydnum repandum (Linn.) Fr., *W.*, *D.*, and var. rufescens (Pers.) Fr., *D.*
Acia uda (Fr.) Bourd. & Galz., *W.*, *C.*, fusco-atra (Fr.) Pat., *C.*, *D.*
Grandinia helvetica (Pers.) Fr., *C.*, *D.*
Odontia fimbriata (Pers.) Fr., *C.*, barba-Jovis (With.) Fr., *D.*, farinacea (Pers.) Quél., *D.*
Hypochnus ferrugineus (Pers.) Fr., *C.*, *D.*, *M.*, fuscus (Pers.) Fr., *D.*, subfuscus Karst., *M.*, rubiginosus Bres., *D.*, fumosus Fr., *D.*
*Tomentellina ferruginosa v. Hoehn. & Litsch., *D.*
Stereum spadiceum Fr., *W.*, sanguinolentum (A. & S.) Fr., *D.*, hirsutum (Willd.) Fr., *W.*, *C.*, *D.*, *M.*, *H.*
Hymenochaete rubiginosa (Dicks.) Lév., *M.*
Corticium fuciforme (Berk.) Wakef. on *Festuca ovina*, *H.*, arachnoideum Berk., *D.*, *byssinum (Karst.) Massee, *D.*, atrovirens Fr., *D.*, botryosum Bres., *D.*, flavescens (Bon.) Massee, *M.*, confine Bourd. & Galz., *D.*, *M.*, fastidi osum (Fr.) Bourd. & Galz., *H.*, porosum Berk. & Curt., *D.*
Peniophora Aegerita v. Hoehn. & Litsch., *W.*, subalutacea (Karst.) v. Hoehn. & Litsch., *D.*, sanguinea (Fr.) Bres., *D.*, velutina (DC.) Cooke, *C.*, *D.*, *M.*, setigera (Fr.) Bres., *C.*, *D.*, hydnoides Cooke & Massee, *D.*, cinerea (Fr.) Cooke, *M.*, quercina (Pers.) Cooke, *C.*, *D.*, *M.*, *L.*
Coniophora puteana Fr., *D.*
Cyphella capula (Holmsk.) Fr., *W.*
Clavaria cristata (Holmsk.) Fr., *M.*, cinerea (Bull.) Fr., *C.*, *D.*, *M.*, gigaspora Cotton, *M.*, amethystina (Batt.) Fr., *M.*, rugosa (Bull.) Fr., *C.*, *M.*, Kunzei Fr. (together with a dwarfed form which is C. Krombholzii Fr.), *M.*, corniculata (Schaeff.) Fr., *M.*, fusiformis (Sow.) Fr., *W.*, *M.*, luteoalba Rea, *M.*, inaequalis (Müll.) Fr., *W.*, *M.*, *H.*, vermicularis Fr., *M.*, pistillaris (Linn.) Fr., *H.*, tenuipes Berk. & Br., *M.*
Auricularia mesenterica (Dicks.) Fr., *C.*, *L.*, auricula-Judae (Linn.) Schroet., *D.*
Tremella mesenterica (Retz.) Fr., *C.*, *D.*, *H.*
Exidia nucleata (Schw.) Rea, *C.*
Tremellodon gelatinosum (Scop.) Pers., *C.*
Sebacina incrustans (Pers.) Tul., *M.*, *H.*
Eichleriella spinulosa (Berk. & Curt.) Burt, *C.*
Tulasnella (Gloeotulasnella) hyalina v. Hoehn. & Litsch., *C.*
Dacryomyces deliquescens (Bull.) Duby, *W.*, *D.*, chrysocomus (Bull.) Tul., *D.*
Femsjonia luteoalba Fr., *C.*, *D.*
Calocera viscosa (Pers.) Fr., *C.*, cornea (Batsch) Fr., *W.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *C.*, *D.*, *M.*
Lycoperdon depressum Bon., *C.*, *M.*, *L.*, umbrinum Pers., *W.*, perlatum Pers., *W.*, pyriforme (Schaeff.) Pers., *W.*, *D.*, *H.*
Crucibulum vulgare Tul., *W.*, *D.*
Cyathus striatus (Huds.) Pers., *W.*, *C.*, *D.*, *H.*
Scleroderma aurantium Pers., *M.*, verrucosum (Vaill.) Pers., *C.*, *D.*, *H.*, *L.*
Sphaerobolus stellatus (Tode) Pers., *W.*

UREDINEAE.

Uromyces Fabae (Pers.) de Bary, *Hereford*, Valerianae (Schum.) Fuck., *H.*, Dactylidis Otth., *L.*

Puccinia Violae (Schum.) DC., *D.*, *H.*, Lychnidearum Link, *W.*, Pruni-spinosae Pers., *L.*, *Hereford*, pulverulenta Grev., *W.*, *D.*, Circaeae Pers., *L.*, Aegopodii (Schum.) Mont., *L.*, Saniculae Grev., *D.*, punctata Link, *H.*, obtegens (Link) Tul., *W.*, Cirsii Lasch, *W.*, Taraxaci Plowr., *D.*, Veronicae Schroet. on *V. montana*, *M.*, Glechomatis DC., *W.*, *M.*, *L.*, Menthae Pers., *W.*, *H.*, annularis (Str.) Schlecht., *W.*, Iridis (DC.) Wallr., *D.*, obscura Schroet., *C.*, Caricis (Schum.) Rebent., *M.*, Lolii Niels., *D.*, *L.*, Poarum Niels., *W.* (aecidium).

Phragmidium subcorticium (Schrank) Wint., *H.*, violaceum (Schultz) Wint., *W.*, *L.*

Kuehneola albida Magnus, *H.*

Coleosporium Sonchi-arvensis (Pers.) Lév., *D.*, Tussilaginis (Pers.) Kleb., *W.*

Pucciniastrum Circaeae (Schum.) Schroet., *W.*, *C.*, *D.*, *H.*, *L.*, Epilobii (Pers.) Otth., *W.*

Melampsora Larici-populina Kleb., *D.*, *H.*

Melampsoridium betulinum (Pers.) Kleb., *W.*, *C.*, *D.*

USTILAGINEAE.

Ustilago Scabiosae (Sow.) Wint., *H.*

Sphacelotheca Hydropiperis (Schum.) de Bary, *W.*

Entyloma Ranunculi (Bon.) Schroet., *D.*

PYRENOMYCETES.

Ctenomyces serratus Eidam, *D.*

Sphaerotheca pannosa (Wallr.) Lév., *W.*, *D.*, *H.*, Castagnei Lév. on *Arctium*, *D.*, *H.*

Podosphaera Oxyacanthae (DC.) de Bary, *C.*, *H.*, leucotricha (Ell. & Ev.) Salm., *Hereford*.

Erysiphe Cichoracearum DC. on *Myosotis*, *H.*, Polygoni DC. on *Circaea*, *W.*, *C.*, on *Hypericum*, *D.*, *H.*

Uncinula Aceris (DC.) Sacc., *C.*, *D.*, *H.*

Phyllactinia corylea (Pers.) Karst., *H.*, *L.*

Nectria cinnabarina (Tode) Fr., *H.*, Peziza (Tode) Fr., *M.*

Hypomyces aurantius (Pers.) Tul., *M.*

Hypocrea gelatinosa (Tode) Fr., *D.*, citrina (Pers.) Fr., *D.*

Claviceps purpurea (Fr.) Tul. on *Brachypodium*, *W.*, on *Arrhenatherum* and *Dactylis*, *L.*, on *Avena*, *D.*, microcephala (Wallr.) Wint., *D.*

Cordyceps militaris (Linn.) Link, *D.*

Leptospora spermoides (Hoffm.) Fuck., *M.*, *L.*, ovina (Pers.) Fuck., *M.*

Rosellinia mammoidea Cooke, *D.*

Mycosphaerella maculiformis (Pers.) Schroet., *D.*

Venturia Rumicis (Desm.) Wint., *W.*

Leptosphaeria acuta (Moug. & Nestl.) Karst., *W.*

Melanconis stilbostoma (Fr.) Tul., *H.*

Cryptosphaeria eunomia (Fr.) Fuck., *H.*

Diatrypella quercina (Pers.) Nke., *W.*, *C.*, *D.*

Diatrype Stigma (Hoffm.) de Not., *W.*, *M.*, disciformis (Hoffm.) Fr., *M.*

Hypoxylon multiforme Fr., *D.*, fuscum (Pers.) Fr., *W.*, *H.*, argillaceum (Pers.) Berk., *D.*, coccineum Bull., *M.*

Daldinia concentrica (Bolt.) Ces. & de Not., *W.*, *C.*, *M.*

Xylaria Hypoxylon (Linn.) Grev., *C.*, *L.*, polymorpha (Linn.) Grev., *H.*

Phyllachora graminis (Pers.) Fuck., *W.*

Endodothella Junci (Fr.) Theiss. & Syd., *W.*

Dothidella Ulmi (Duv.) Wint., *L.*

HYSTERIALES.

Dichaena quercina Fr., *M.*

Rhopographus Pteridis (Sow.) Wint., *W.*, *D.*, *M.*

DISCOMYCETES.

Leptopodia ephippium (Lév.) Boud., *D.*
Peziza aurantia Pers., *W.*, *C.*, *D.*
Sarcoscypha coccinea (Jacq.) Fr., *M.*
Ciliaria scutellata (Linn.) Quél., *W.*, *D.*, *M.*, *H.*
Cheilymenia dalmeniensis (Cooke) Boud., *W.*, *D.*
Coprobia granulata (Bull.) Boud., *D.*
Exoascus alnitorquus (Tul.) Sadeb., *W.*
Trichoglossum hirsutum (Pers.) Boud., *M.*
Microglossum viride (Pers.) Gill., *M.*
Leotia lubrica (Scop.) Pers., *C.*
Calycella claroflava (Grev.) Boud., *D.*, *M.*
Coryne sarcoides (Jacq.) Tul., *W.*, *M.*
Bulgaria inquinans (Pers.) Fr., *W.*, *D.*, *M.*
Orbilia luteo-rubella (Nyl.) Karst., *W.*, xanthostigma Fr., *C.*, *M.*
Sclerotinia Curreyana (Berk.) Karst., *M.*
Chlorosplenium aeruginosum (Oeder.) de Not., *D.*
Helotium herbarum (Pers.) Fr., *W.*, *H.*, fructigenum (Bull.) Fuck., *H.*, scutula (Pers.) Karst., *W.*
Cyathicula coronata (Bull.) de Not., *W.*
Dasyscypha virginea (Batsch) Fuck., *W.*, *D.*, pulverulenta (Lib.) Sacc., *D.*
Arachnopeziza aurelia (Pers.) Fuck., *D.*, aurata Fuck., *D.*
Trichoscypha calycina (Schum.) Boud., *L.*
Hyaloscypha hyalina (Pers.) Boud., *D.*
Urceolella puberula (Lasch) Boud., *W.*
Mollisia cinerea (Batsch) Karst., *W.*, *D.*, *M.*, melaleuca (Fr.) Sacc., *D.*
Catinella olivacea (Batsch) Boud., *M.*
Pseudopeziza Trifolii (Biv.-Bern) Fuck., *D.*, Ranunculi (Wallr.) Fuck., *D.*
Stegia Ilicis Fr., *W.*
Rhytisma acerinum (Pers.) Fr., *C.*, *D.*

PHYCOMYCETES.

Syzygites megalocarpus Ehrb., *W.*, *D.*
Phytophthora infestans (Mont.) de Bary, *Hereford.*
Peronospora alta Fuck., on *Plantago media*, *D.*, *H.*

SPHAEROPSIDALES.

Phyllosticta hedericola Dur. & Mont., *H.*
Actinonema Rosae (Lib.) Fr., *D.*, *Hereford.*
Septoria Rubi West., *W.*, *D.*, castanicola Desm., *D.*
Gloeosporium nervisequum (Fuck.) Sacc., *L.*
Libertella faginea Desm., *M.*
Vermicularia trichella Fr., *H.*, Holci Syd., *L.*

HYPHOMYCETES.

Monilia aurea (Link) Gmel., *D.*, *M.*, fructigena Pers., *Hereford*, cinerea Bon., *Hereford.*
Oidium alphitoides Griff. & Maubl., *W.*, *C.*, *D.*, *H.*
Ovularia obliqua (Cooke) Oud., *W.*, *H.*
Rhinotrichum Thwaitesii Berk. & Br., *M.*
Trichoderma viride (Pers.) Fr., *W.*, *D.*
Botrytis cinerea Pers., *Hereford.*
Ramularia calcea (Desm.) Ces., *W.*, *C.*, *D.*, *M.*, *L.*, Epilobii Allesch., *D.*, Circaeae Allesch., *D.*, plantaginea Sacc. & Berl., *D.*, Primulae Thuem., *W.*, *D.*, *H.*, sambucina Sacc., *W.*, Urticae Ces., *W.*, Taraxaci Karst., *D.*, *H.*
Bispora monilioides Corda, *C.*, *H.*
Hormodendron cladosporioides (Fres.) Sacc., *H.*
Fusicladium dendriticum Fuck., *D.*
Heterosporium gracile Sacc., *D.*
Cercospora Mercurialis Pass., *C.*
Stilbella erythrocephala (Ditm.) Lind., *D.*, *H.*
Tilachlidium tomentosum (Schrad.) Lind., *W.*
Isaria farinosa Fr., *D.*

MYCETOZOA GATHERED DURING THE HEREFORD FORAY.

By G. Lister, F.L.S.

FINE weather prevailed during the five days of the Foray. On Monday, September 27th, Mr St John Marriott collected alone in woods near Dinedor Camp, and found five species; amongst them was *Trichia verrucosa*, which is not often met with. On September 28th the party visited Wormesley Woods in the morning and Credenhill in the afternoon. The chief feature in the Wormesley Woods was a chain of partly dry ponds bordered by oaks; on the branches and twigs which had fallen and lay half-buried in mud and dead leaves by the water's edge were large growths of *Oligonema nitens*, the minute sporangia being heaped together to form conspicuous clusters. Such half-submerged wood is a well-known habitat for this species. On Credenhill some old coniferous stumps under ash and oak yielded *Cribaria argillacea* and *Tubifera ferruginosa*. On September 29th we visited Dinmore Woods, consisting chiefly of tall oaks with an undergrowth of bramble, on high ground; fifteen species of Mycetozoa were found, of which *Fuligo muscorum*, *Diderma floriforme* and a large development of *Stemonitis herbatica* were the most noteworthy. On September 30th we drove to Moccas Old Park; under some of the great oaks and beeches on the grassy slopes of the park, were lying, half-hidden among bracken, huge decaying oak trunks abounding with Mycetozoa; thirteen species occurred on one trunk alone, among them being *Lycogala conicum*, a new record for the British Isles. This species is nearly allied to the very frequent *L. epidendrum* but may be recognised in the field by the neat conical shape of the aethalia and the dark-veined cortex.

In the accompanying list of the forty-one species found during the Foray the localities are indicated by the following initials: *DC.* stands for Dinedor Camp; *W.* for Wormesley Woods; *C.* for Credenhill; *D.* for Dinmore Woods; *M.* for Moccas Old Park; *H.* for Holme Lacy, visited on Friday's expedition.

Ceratiomyxa fruticulosa (Müll.) Macbr., *DC.*, *M.*
Physarum nutans Pers., *W.*, *M.*, *H.*; subsp. leucophaeum Lister, *W.*; P. viride Pers., *M.*, *H.*; var. aurantium Lister, *D.*
Fuligo septica Gmel., *W.*, *H.*; var. candida R.E.Fries, *M.*; F. muscorum Alb. & Schw., *D.*
Craterium minutum (Leers) Fr., *DC.*, *W.*
Diderma floriforme Pers., *D.*
Didymium difforme (Pers.) Duby, *W.*, *M.*, *H.*; D. squamulosum (Alb. & Schw.) Fr., *DC.*; D. Clavus (Alb. & Schw.) Rabenh., *DC.*
Mucilago spongiosa (Leyss.) Morg., *M.*
Stemonitis fusca Roth, *W.*, *D.*, *M.*, *H.*; var. confluens Lister, *M.*; S. herbatica Peck, *D.*; S. ferruginea Ehrenb., *W.*, *D.*

Comatricha nigra (Pers.) Schroet., *D.*, *M.*; C. laxa Rost., *M.*; C. elegans Rost., *M.*; C. typhoides (Bull.) Rost., *W.*, *M.*, *H.*
Enerthenema papillatum (Pers.) Rost., *M.*
Cribraria argillacea Pers., *C.*, *M.*, *H.*; C. vulgaris Schrad., *M.*; var. aurantiaca Pers., *M.*
Dictydium cancellatum (Batsch) Macbr., *C.*, *M.*; var. fuscum Lister, *M.*
Tubifera ferruginosa Gmel., *C.*, *M.*
Reticularia Lycoperdon Bull., *D.*
Lycogala epidendrum (L.) Pers., *W.*; L. conicum Pers., *M.*
Trichia affinis de Bary, *M.*; T. persimilis Karst., *W.*, *D.*, *M.*; T. verrucosa Berk., *DC.*; T. scabra Rost., *W.*, *M.*; T. varia Pers., *M.*; T. Botrytis Pers., *W.*; T. decipiens Pers., *W.*, *D.*, *M.*, *H.*
Oligonema nitens (Lib.) Rost., *W.*
Hemitrichia clavata (Pers.) Rost., *W.*; H. Vesparium (Batsch) Macbr., *M.*
Arcyria cinerea Pers., *W.*, *D.*, *M.*; A. pomiformis (Leers) Rost., *M.*, *H.*
A. denudata (L.) Wettst., *W.*, *D.*, *M.*, *H.*; A. incarnata Pers., *W.*, *D.*; var. fulgens Lister, *M.*; A. nutans (Bull.) Grev., *W.*, *D.*, *M.*

LICHENS OF THE HEREFORD FORAY.

By Robert Paulson, F.L.S., F.R.M.S.

THE ground covered by the Foray included a considerable acreage of woodlands situated to the north, west and south-east of our headquarters in the town and at distances of eight to twelve miles away.

These woods vary widely in character; some at Dinmore (to the north) consist of closely growing trees, for the most part young oak, while others contain trees of great age as the magnificent beeches in the wood around the camp on Credenhill and the veteran oaks, which number their ages in centuries, of the woodlands of Moccas Old Park.

It was one of the great pleasures of the Foray to be free to wander and collect in an ancient woodland which contains such notable trees as the "Hut Oak" and the "Tall Oak" of Moccas, monarchs that have attained a height of 94 ft. and 118 ft. respectively.

Woods of young oak yielded little or no lichen material, but the veterans of the Park were mostly covered with species of *Parmelia*, *Ramalina*, *Physcia* and *Pertusaria*.

An old fence which stretches for a considerable distance along one side of Moccas Old Park well repaid the close scrutiny that was devoted to it. On the west side of the palings was an abundance of *Bilimbia caradocensis* (studded with numerous apothecia), *Cyphelium inquinans*, *Usnea florida* var. *hirta* and *Physcia hispida*.

The excursion to Mordiford by way of Fownhope covered part of Haugh Wood, Ethelbert's Camp, and included a detour to Holme Lacy. In this locality the outcrop of Silurian Lime-

stone added a few calcareous lichens not seen on the previous days. Perhaps the most frequently noted of these was *Biatorella pruinosa*. On the mortar of an old wall near Fownhope the variety *B. albocincta* occurred.

Other saxicolous species were found upon broken portions of Old Red Sandstone by the sides of ancient cart-ruts, near Wormesley, and on the walls of the disused observation tower on the high ground at Dinmore, where *Acarospora veronensis*, *Lecidea latypea* and *L. goniophila* occurred.

A terricolous species of *Leptogium* collected from a moderately light clay loam of the heathland, Dinmore, agrees very closely with the original description of *Collema cataclystum* Koerb. = *Leptogium cataclystum* Nyl. Its dark olivaceous-fuscous thallus is adnate, laciniate-lobate and crenate. The narrow laciniae occasionally broaden and become wedge-shaped and even hooded. When dry the thallus is hard, but when moistened it becomes decidedly turgid.

It has not been possible to compare this lichen with a type specimen of *Leptogium cataclystum*, but in three Hungarian specimens, from two different localities, we note it can be inferred that the colour, the degree of segmentation and the attachment of the thallus to the substratum, vary within considerable limits.

The home specimen is more closely adnate to the substratum, is darker in colour and more finely laciniate than those from Hungary, and there is in the foreign specimens a nearer approach to the moniliform arrangement of gonimia than is the case in the Hereford lichen.

It is in repect of the spores that the Hungarian and the British species so closely agree. In both they are elliptical-ovate in shape, clearly blunt at one end, frail in appearance, 22–30 μ long, 8–12 μ wide and the muriform cells which number 8–10 are often ill defined. The arrangement of the elliptical spores, end to end, in a chain within a cylindrical-clavate ascus is a striking feature of these lichens.

It is more particularly upon the spore characters that I have included *Leptogium cataclystum pro tem.* in the list of lichens of the Hereford Foray.

The most interesting lichen collected on this occasion is one from Fownhope, described below.

Bilimbia sublubens n. sp.

Thallus effusus, sat tenuis, subareolato-granulosus, obscuro-virescens, K—, CaCl—. Apothecia parva, diam. 0·5–1·0 mm., adnata, planiuscula, margine leviter elevato cincta; hypothecium subincoloratum; paraphyses paucae, facile liberae,

ad apicem plus minus nigricanti-smaragdulae v. sordide olivascentes, flexuosae, ramosae, graciles. Asci clavati 90–110 $\mu \times$ 16–18 μ, sporae 7–9 septatae, subfusiformes, elongatae, rectae, v. leviter curvulae, 35–48 $\mu \times 7\mu$. I. vinose rubet.

This lichen was growing among others on the upper side of the middle bar of an ordinary farm five-barred gate. It was open to the full light of the sun but exposed to clouds of dust from a high road.

It clearly belongs to *Bilimbia* (Lecideaceae) and to the *B. sabuletorum* group. It approaches *B. Nitschkeana* Lahm. in the granulose, greyish thallus, the colourless hypothecium, and the scanty, flexuous, branched, discrete paraphyses. On the other hand, it resembles *B. lubens* A.L.Sm. in the septation (5–9 septa) and in the large size of the spores, which measure 28–50 μ long and 7–11 μ thick.

The letters placed after the names of the species and varieties indicate the localities in which the lichens were collected, viz. *W.* = Wormesley and Credenhill, *D.* = Dinmore, *M.* = Moccas Old Park, *H.* = Haugh Wood, *E.* = Ethelbert's Camp, and *F.* = Fownhope.

The list includes ninety-eight species and varieties. *Bilimbia sublubens* n.sp., and *Leptogium cataclystum* are new to Great Britain and *Biatorella pruinosa* var. *albocincta* is recorded as of rare occurrence; it is possible that it may have been overlooked.

I am much indebted to Miss A. Lorrain Smith for the help she has given respecting the determination of critical species, and to Mr H. H. Knight for placing his lists, with notes, at my disposal.

CALICIACEAE.

Chaenotheca melanophaea Zwackh., *W.*, *D.*
Calicium hyperellum Ach., *M.*, *W.*, *D.*
Cyphelium inquinans Trev., *D.*, *M.*, *E.*

COLLEMACEAE.

Collema pulposum Ach., *D.*
C. tenax Sm., *H.*
C. multifidum Schaer., *D.*
Leptogium cataclystum Koerb., *D.*

PELTIGERACEAE.

Peltigera canina Willd., *W.*, *M.*

PARMELIACEAE.

Parmelia physodes Ach., *D.*, *W.*
P. caperata Ach., *M.*
P. saxatilis Ach., *W.*, *D.*, *M.*
P. saxatilis f. furfuracea Schaer., *M.*
P. sulcata Tayl., *W.*, *M.*
P. dubia Tayl., *W.*, *D.*
P. fuliginosa Nyl. var. laetevirens Nyl., *W.*, *D.*, *M.*

USNEACEAE.

Evernia prunastri Ach., *W.*, *D.*, *M.*
Ramalina calicaris Fr., *W.*, *M.*
R. fastigiata Ach., *M.*
R. farinacea Ach., *M.*
Usnea florida Web., *W.*
U. florida var. hirta Ach., *W.*, *M.*

PHYSCIACEAE.

Xanthoria parietina Th. Fr., *W.*, *M.*
Placodium murorum DC., *E.*
P. citrinum Hepp, *W.*, *D.*
P. aurantiacum Anzi var. flavovirescens Hepp., *E.*
P. pyraceum Anzi, *D.*
P. rupestre Branth. & Rostr., *H.*, *F.*
Candelariella vitellina Müll.-Arg., *W.*, *D.*
Physcia ciliaris DC., *W.*
P. pulverulenta Nyl., *M.*
P. stellaris Nyl. var. cercidia Th.Fr., *M.*
P. hispida Tuckerm., *W.*, *F.*

P. erosa Leight., *M.*
P. caesia Nyl., *W.*, *M.*
Rinodina sophodes Th.Fr., *M.*
R. exigua S.F.Gray, *W.*, *M.*, *F.*
R. demissa Arn., *W.*, *D.*, *H.*

LECANORACEAE.

Lecanora muralis Schaer., *F.*
L. subfusca Nyl. var. allophana Ach. *W.*, *D.*
L. rugosa Nyl., *W.*
L. campestris D.de Lesd., *D.*, *F.*
L. atra Ach., *D.*, *M.*
L. Hageni Ach., *W.*, *F.*
L. galactina Ach., *H.*, *F.*
L. varia Ach., *W.*, *D.*, *M.*
L. symmicta Ach., *W.*, *D.*
L. symmictera Nyl., *M.*
L. parella Ach., *H.*, *S.*
Acarospora veronensis Massal., *D.*
Lecania albariella A.L.Sm., *M.*

PERTUSARIACEAE.

Pertusaria faginea Leight., *W.*, *M.*
P. pertusa Dalla Torre & Sarnth., *W.*, *M.*
P. leioplaca Schaer., *D.*
P. Wulfenii DC., *M.*

THELOTREMACEAE.

Phlyctis agelaea Koerb., *W.*

CLADONIACEAE.

Baeomyces rufus DC., *W.*
Cladonia sylvatica Hoffm., *D.*
C. pyxidata Hoffm., *D.*
C. fimbriata Fr., *W.*, *D.*
C. furcata Schrad., *W.*
C. macilenta Hoffm., *D.*

LECIDEACEAE.

Lecidea ostreata Schaer., *D.*, *M.*
L. quernea Ach., *M.*
L. coarctata Nyl., *W.*, *D.*
L. mutabilis Fée, *F.*
L. fuscorubens Nyl., *H.*
L. parasema Ach., *W.*
L. latypea Ach., *D.*
L. goniophila Schaer., *D.*
L. crustulata Koerb., *W.*
Biatorella pruinosa Mudd, *H.*, *F.*
B. pruinosa f. nuda A.L.Sm., *F.*
B. pruinosa var. albocincta A.L.Sm., *F.*
Biatorina Griffithii Massal., *M.*
Bilimbia caradocensis A.L.Sm., *M.*
B. sublubens nov. sp., *F.*
Buellia canescens de Not., *M.*
B. myriocarpa Mudd, *W.*
Leciographa parasitica Massal., *M.*
Rhizocarpon alboatrum Th.Fr., *W.*, *M.*
R. alboatrum var. epipolium A.L.Sm., *W.*
R. petraeum Massal., *H.*, *E.*
R. obscuratum Massal., *W.*

ARTHONIACEAE.

Arthonia radiata Ach. var. Swartziana Syd., *W.*

GRAPHIDIACEAE.

Opegrapha herpetica Ach., *M.*
O. atra Pers., *M.*
O. atra var. denigrata Schaer., *M.*
O. betulina Sm., *H.*
O. saxicola Ach., D.
O. vulgata Ach., *H.*
Graphis elegans Ach., *W.*

VERRUCARIACEAE.

Verrucaria aethiobola Wahlenb. var. acrotella A.L.Sm., *D.*
V. papillosa Ach., *H.*
V. viridula Ach., *F.*
V. nigrescens Pers., *W.*, *M.*
V. glaucina Ach., *F.*
V. muralis Ach., *H.*
V. integra Carroll, *F.*

PYRENULACEAE.

Arthopyrenia fallax Arn., *W.*, *D.*
A. submicans Arn., *W.*

PRESIDENTIAL ADDRESS.

By George H. Pethybridge.

MYCOLOGY AND PLANT PATHOLOGY.

THE BRITISH MYCOLOGICAL SOCIETY was founded on September 19th, 1896, so that our present Foray falls near its thirtieth birthday. The Woolhope Naturalists' Field Club, in happy conjunction with which this meeting is being held, had, for some quarter of a century before the birth of our Society, been conspicuous for the success of its fungus forays, and our activities may be looked upon to some extent as a continuation and expansion of those of that club. My own connection with the Society has been but a slender one. Having till recently been resident out of England for over twenty years, I have not been able to enjoy to the full the privileges of membership. However, I now find myself in the exalted position of President, an honour which involves the delivery of a presidential address.

I cannot deal in detail with the Society's history during the past thirty years, or review the progress of mycology the world over and assess exactly the part that the Society has played in the advance of our knowledge of fungi during that period. My own career has been more that of a botanical "maid-of-all-work" than that of a mycologist, and thus I possess inadequate qualifications for such a task. This is the less to be regretted, however, since one of our past Presidents, Mr Carleton Rea, covered this ground in his address in 1922.

In casting about for a peg on which to hang a few remarks appropriate to the present occasion, the motto of the Society "Recognosce notum, ignotum inspice," which I read as meaning "Nod to the known, study the strange," suggested itself.

Now Nature is never at a standstill, change and development are always in progress; evolution still proceeds, consequently the number of the "ignotum" can never be an absolutely finite quantity. Nevertheless, since the birth of new species is relatively a slow process, the "ignotum"—provided that the hunt continues—must steadily diminish and the "notum" constantly increase.

In proof of this I need but recall, so far as this country is concerned, such events as the publication in 1913 of W. B. Grove's volume on the *British Rust Fungi*, and of Carleton Rea's *British Basidiomycetae* in 1922. Further, there are Miss Lorrain Smith's Monograph of *British Lichens* and Miss Lister's on the *Mycetozoa*, both of which in revised or completed form have appeared during the current year. Reference might also be

made to Mr Ramsbottom's *List of British Discomycetes* published some years ago, and to other lists and notes published during recent years.

The "ignotum," therefore, is rapidly diminishing, and must eventually disappear almost entirely. There will, of course, always be individuals to whom the "ignotum" will be large, and to such the prosecution of the Society's work along its present main lines will always be of the utmost value; but are there not other paths that might perhaps be followed with advantage?

Let us see how the pursuit of our motto works out in actual practice, assuming that our Forays constitute the most important part of our activities; they are certainly the oldest. We select special localities and are guided almost entirely by the availability of woodland areas in the district chosen. In such surroundings we expect to find an abundant mycological flora, especially of the higher forms. We list those we know at sight, we examine in detail the less well known, and, after identification, add them to the list. The longer the list the happier we are.

Now, I would not underestimate the joy of recognising old fungus friends, and of making new ones. Nor must one forget the chances of recording species hitherto not found here, or of discovering others new to science.

But the making of mere inventories—important in their way as they are—must at some time come to an end; and the question is whether the time is not at hand when we may feel satisfied that our British fungal census is reasonably complete. If that be so, should not some of our energies be diverted into other channels?

The phanerogamic flora of the British Isles is now pretty thoroughly known. The distribution of the various species has been worked out in considerable detail. The proportion of "notum" to "ignotum" is very large indeed. But the study of flowering plants in the field has not come to a halt; it has taken a new direction. Instead of merely recording the presence or absence of species in political areas such as counties, provinces or kingdoms, those living in consort within naturally defined habitats have been grouped, the conditions prevailing in such habitats studied and the relationships of the plants to their environment examined.

This is study on ecological lines, and it leads ultimately to an examination of the bionomics of each species, involving in some cases even that of the individual itself. Something of this kind has already been begun amongst fungi, as the recently published and intriguing work of Professor A. H. R. Buller testifies. His three lengthy but stimulating volumes of *Researches on Fungi*

bristle with new and ingenious ideas, and reveal many aspects of mycology which have hitherto claimed all too little attention.

Botanists everywhere have been busy in recent years in the study of vegetation, but to what extent has the position occupied by cryptogams in the scheme of affairs been studied? To a relatively very small extent; and the mycological aspects have been almost entirely neglected. In that pioneer book, *Types of British Vegetation*, published some years ago, the word *fungus* does not occur in the general index, nor does the name of any fungus occur in the index of plant names. In the preface it is stated, "the lower plants generally are, for the most part, mainly through want of knowledge, very inadequately treated, and in the case of many plant communities, ignored altogether. This is greatly to be regretted, since these plants are frequently of the first importance in differentiating plant communities."

Here, then, there would appear to be considerable scope for mycological survey and endeavour. In some respects the work would not at first differ essentially from that hitherto accomplished; for lists of the genera and species of fungi accompanying the other members of the plant communities would have to be prepared. It is possible that preliminary lists could be compiled now from existing data, without additional field work; but for the study of the relationships of the fungi to the remainder of the flora in the association and to the other factors of their environment, further field work is essential, and it would probably have to be supplemented by work in the laboratory.

The fact that fungi are saprophytic or parasitic, and are specialised in regard to the substrata on which they flourish would render such a study all the more fascinating, although certainly not less difficult. Moreover, such studies would have to reckon not only with those forms with conspicuous fructifications, but also with those involving the use of the microscope for their elucidation. Finally, the examination of the associations from the mycological point of view would have to be frequent and more or less continuous, otherwise some forms might escape attention altogether, since fungi, on the whole, are much more evanescent in their appearances than most of the higher plants.

The idea of arranging fungus forays to salt marshes, sand dunes, bogs, heaths, moors, arctic-alpine mountain-tops and other such places, instead of confining them more or less to associations of the woodland type may perhaps appear to be a preposterous one. The bag would be too small, the lists too attenuated and in general "the game not worth the candle"! Nevertheless, there can be no question but that the study of fungi from their ecological and bionomic aspects offers great

possibilities, and is a field which has hitherto been relatively neglected*.

I turn now from this important side of the Society's activities to a more specialised and technical one, namely, plant pathology. If we try to trace the development of this subject in this country we shall find that at one time mycology was regarded as of little or no importance in relation to the causation of plant diseases. In the earlier days of Berkeley, who may be regarded perhaps as the founder of phytopathology in this country, the idea that plant diseases were caused by fungi was by no means widely accepted. On the contrary, any fungi which might occur in connection with disease were regarded as the *result* of such disease, not the cause of it. Thus, when the potato blight first appeared here in the 'forties of last century, a very considerable and important band of scientific men vigorously opposed the idea that the blight could be caused by a fungus. Berkeley, however, was one of a small minority of men of real insight, who shared his opinion when he maintained (*Journ. Hort. Soc. Lond.* 1 (1846), p. 23) that "the decay is the consequence of the presence of the mould, and not the mould of the decay"—a view which subsequently proved to be correct.

This was in 1846. By 1860 matters had progressed considerably and Berkeley then wrote: "Fungi were long regarded as the mere creatures of putrescence, and therefore as the consequence, not the cause of disease. A more intimate acquaintance with their structure and habits has, however, removed much of this prejudice, and almost everyone is now ready to acknowledge what a weighty influence they have in inducing diseased condition, both in the animal and vegetable world." Such are the opening sentences of Chapter x of Berkeley's *Outlines of British Fungology*, and a perusal of this chapter at the present day enables one to realise something of the extent to which plant pathology has advanced during the past half-century or so. So far as bacteria are concerned, however, it was not till 1901 that the possibility of their being capable of causing disease in plants was eventually conceded on all sides. To-day the pendulum has swung far in the other direction; in the opinion of some, perhaps too far; because ever-increasing attention has been paid to the parasite as the cause of disease, whilst other factors have tended to suffer somewhat from neglect.

Disease in plants is the result of disharmony between the plant and its environment. A parasite, of course, if present, is part of the plant's environment considered in its widest sense.

* Since the above was written, an article on the Ecology of Fungi by J. Ramsbottom has appeared in the *Aims and Methods in the Study of Vegetation*, the handbook of the British Empire Vegetation Committee.

But if we treat it as a separate or special factor, we then get the eternal triangle, host, parasite and environment. Nor must it be forgotten that both host and parasite are to some extent variable or unstable, and that the fluctuating factors of the environment may influence the parasite as well as the host.

In spite of this complexity, however, it is still true that the parasite is often the most important factor in disease production; hence the intimate connection between mycology and plant pathology remains, a connection well brought out by Mr F. T. Brooks in his Presidential Address delivered at the Keswick Autumn Foray in 1922. So close is the relationship between the two that, in this country at any rate, plant pathologists are often—and some of them, indeed, officially—called mycologists. This, however, is somewhat of a misnomer; for it will be evident that a plant pathologist must be something other than a pure mycologist, if he is to be worthy of his name and profession.

A mistake frequently made is to confuse the name of a disease with the name of the parasite, confusing, that is, practically, effect with cause. The most recent example of this lack of discrimination that I have seen occurs in a publication issued by the United States of America Federal Horticultural Board entitled *Foreign Plant Diseases*. This bulletin consists essentially of a list of, perhaps, 10,000 names of presumably parasitic fungi, bacteria and eelworms, arranged according to hosts, and covering one hundred and ninety-six closely-printed pages. The parasites mentioned are said either not to occur or not to be widely distributed in the U.S.A. It is certainly not a list of plant diseases. It may perhaps frighten some persons to think of the enormous number of plant diseases that might develop in their midst, but to pathologists such a list appears much less formidable, especially when regard is paid to the fact that host, parasite *and* environmental conditions all play a part in the production of disease.

That the physical factors of the environment are often of considerable and in some cases of paramount importance in the inception and spread of disease in plants, plant pathologists and growers of plants know well. For instance, in the absence of certain conditions of atmospheric moisture and temperature, even in the presence of the respective parasites, the "damping off" disease of seedlings, due to *Pythium*, does not occur; *Botrytis* does little or no harm in the glass house; potato blight may not appear at all, or, if it does, may not become epidemic; celery leaf spot remains practically harmless; beans remain free from Chocolate Spot disease, and so on. Briton-Jones has recently brought forward evidence to show that the Die-back of fruit trees is probably the result of preliminary enfeeblement

due either to excessive or to insufficient soil moisture and followed by weak parasites, such as *Diaporthe* and *Cytospora*, rather than the consequence of primary virulent parasitism.

Again, physical climatic factors—temperature for instance—sometimes play a decisive part in determining whether a specific disease may or may not prevail in a particular region. The spores of *Urocystis Cepulae*, the fungus which causes Onion Smut, do not germinate readily above 25° C. and not at all above 29° C. Hence this disease is of little or no importance in hot climates, and is confined to cooler ones. Species of *Fusarium* and *Verticillium* which cause wilts of potatoes, tomatoes, flax, etc., differ in their temperature relations. Thus, Flax Wilt, due to *F. Lini*, is a very serious disease in parts of the United States of America. In the North of Ireland, however, although the fungus is present there, the disease is practically negligible, owing to the relatively cooler summers. *Verticillium* Wilt of the potato is a disease of relatively cool climates and is met with to some extent in this country, whereas the *Fusarium* Wilt, depending on a higher temperature, is, so far as I am aware, unknown in this country, although it occurs in Central Europe and in the warmer parts of America.

Climatic and weather conditions cannot yet, of course, be regulated by man, although attempts to modify their influence have not been entirely wanting. When, however, plants are grown under glass it is possible, to a considerable extent, to control soil and atmospheric temperature and humidity as well as light intensity; and the most successful grower is he who can so control these conditions as to avoid disease and get a maximum crop. Here the scope for pathological research is wide, because there is still a great lack of exact scientific knowledge as to the precise conditions which favour or impede the onset of the various diseases of glass-house crops.

In recent years a good deal of experimental work has been done in connection with the artificial enrichment with carbon dioxide of the atmosphere in which plants are growing; furthermore, the study of the effect of electricity on crops has been fairly intensively pursued of late. True, investigations on these lines have been proceeding mainly—if not entirely—from the point of view of crop yield; nevertheless, it is not impossible that environmental factors of these kinds may have some connection with the problems of disease, and plant pathologists should therefore not lose sight of them.

With regard to chemical factors, there is a much wider scope for intervention, for the manuring of a crop may be varied almost to any extent. We know, for instance, that excessive nitrogenous manuring disposes cereals to rusts, turnips and

swedes to bacterial rot and, in general, seems to undermine the power of plants to resist the attacks of parasites. Similarly, lack of potash may dispose towards parasitic disease, as for instance, rust in mangolds and beet. On the other hand, lack of this element may also lead to disease in which parasites are not concerned, as recent research is tending to show with leaf-scorch of fruit trees, although here other factors may perhaps also be concerned. Lime, or the soil alkalinity produced by it, may be the chief factor in inducing the parasites which cause ordinary and powdery scabs respectively to assert themselves and attack potato tubers. On the other hand, through its agency crucifers may be grown free from Finger-and-Toe disease; not because it is directly lethal to the parasite—for recent research has shown that this is probably not the case—but for some other reason not as yet fully understood.

Although an enormous amount of work has been done on soils and manuring from the chemical point of view, very little of it has had any special bearing on plant pathology. It has often struck me that there is a field of work here for the pathologist well worthy of closer attention and one which might yield important and far-reaching results.

Some ten or fifteen years ago a considerable amount of attention was being devoted to the study of the effect of dosing crops with relatively minute quantities of certain chemical substances (*not* the old salts of K, N, P) which appeared to act in some way as a decided stimulus to growth and development. If I remember rightly, a good deal of work of this kind was done in Japan with the rice crop. But the alleged stimulating action of such substances was also studied to some extent in this country; for I recollect seeing pot experiments at Woburn in this connection in or about 1912. One series of pots containing wheat struck me very forcibly, in which the stimulating substance was a salt of lithium. As is well known to all who have attempted to grow cereals under glass, it is almost impossible to avoid the development of the common mildew, *Erysiphe graminis*, on the young experimental plants. The cultures at Woburn were no exception in this respect; but the remarkable thing was that the plants in certain pots, watered with a very dilute solution (in the region of 1–3 in 100,000) of a salt of lithium remained free from mildew. So far as I am aware this matter has never been fully followed up, although it seems well worth doing from the pathological point of view and some attention was devoted to it in 1913 by G. T. Spinks (*Journ. Ag. Science*, v (1913), 231).

That the presence or absence of the compounds of certain chemical elements may have a profound influence on the plant is of course well known, but the elements that have been

thoroughly tested in this respect are all too few, and that there is much more to be learned is evidenced by the recent work of Miss Brenchley with boron. In this connection reference may be made to some experiments conducted at Kew more than twenty years ago by G. Massee (*Journ. Roy. Hort. Soc.* XXVIII (1903), 142). It was found that by watering tomato and cucumber plants at regular intervals, with a dilute solution of copper sulphate (1 in 7000) they could be rendered immune from attack by both *Cladosporium fulvum* and *Dendryphium comosum*. The experimental plants were fully exposed to infection, since they surrounded affected plants, and, moreover, they were sprayed with spore-suspensions of the parasites. They remained healthy, however, whilst checks similarly treated but not watered with the copper sulphate solution became badly diseased. The results were explained by saying that "the copper arrests or modifies the production of some substance in the leaves, which favours the entry of the fungus into the plant." Work on somewhat similar lines has been done by E. Marchal in connection with the *Bremia* disease of lettuces, and also by Pichi, Rumm, Viala, Laurent and Hall with other hosts and parasites. In some cases, it is true, the results were not encouraging, but the chemical substances tried were nearly always salts of copper, and the subject cannot be looked upon as at all exhaustively studied. Further work with compounds of other elements might give quite different results; and to me, at any rate, the idea of inducing immunity or resistance in plants by chemical means is an attractive one and worthy of being followed further.

Of course, the factors of a plant's environment, apart altogether from the presence of any parasite, may have a profound effect on the plant itself, and disease may be the direct result of unsuitable environmental conditions. Such diseases—sometimes not very happily referred to as "physiological diseases"—are also the concern of the plant pathologist. But even here care is required or serious errors may be made. Take for example the disease of fruit and other trees known as Silver Leaf. It is characterised by a silvery or leaden sheen in the foliage. Branches die back and often, but not always, the whole tree becomes killed. In former days—as now—in spite of much search, no parasite of any kind could be found in the affected leaves, hence the disease was placed by various English, French and German writers in the non-parasitic category.

Thanks to the work of Percival, Brooks and others in this country, however, we now know with certainty that Silver Leaf is a parasitic disease due to the attacks of *Stereum purpureum*. We know that this fungus gains entry through wounds; we know at what time of the year infection most readily occurs,

and we also know that, just as "love laughs at locksmiths," so *Stereum purpureum* is not prevented from entering a wound by a covering of tar. Other important information has also been discovered concerning this fungus and its host relationships, such as the development of a "gum" barrier which occludes the parasite, and so on. I need not recapitulate the details, but may merely point the moral that here is a disease which for long passed as a non-parasitic one and for which no remedy based on accurate knowledge could be suggested. But with the discovery of its parasitic nature and a knowledge of the behaviour of the parasite itself, we are now in a much better position to deal with the disease than formerly; and proportionately as our understanding of the enemy and his habits is increased by further research, so our power of checkmating him will develop.

After this considerable digression, let me now return to the path of tracing the development of plant pathology in this country. In addition to Berkeley, some of the other mycologists and botanists, whose names will always be remembered in connection with the rise and development of British phytopathology, are M. C. Cooke, C. B. Plowright, Worthington G. Smith and George Massee. The name of Harry Marshall Ward occupies perhaps a special place, for his more important work differed considerably from that of most previous and even contemporaneous workers, in that it was not concerned so much with descriptive accounts of parasites and symptoms of disease as with *experimental investigations* on the disease-producing fungi and their hosts, carried out under controlled conditions. His studies in parasitism have been said to have laid the foundations for all later investigations into the nature of susceptibility and immunity in plants; and his death twenty years ago, at the comparatively early age of fifty-two, was an irreparable loss. His influence, however, still lives and continues to bear fruit.

The further development of plant pathology in this country has been, until recently, comparatively slow, more so, indeed, than in some foreign countries. This may perhaps be accounted for partly by the fact that as compared with the development of our great manufacturing industries, that of agriculture has been to a great extent neglected. But even in industrial matters Britain has been almost notoriously behind-hand, as compared with other progressive nations, in the application of science and scientific methods. A general apathy towards science, a positive dislike to it in some quarters, our habit of "muddling through" our difficulties somehow and of stupidly being proud of doing so, have been characteristic of this country in the past; and much has even yet to be done to enlighten, not only the man in the street, but also some of those in high authority, of the rightful

place of science in our national life. The recent war opened our eyes to the many dangers of the neglect of science, and it is to be hoped that the lessons then learned will not soon be forgotten.

During the latter half of the nineteenth century the importance of plant pests and diseases became increasingly recognised. In 1877 the possibility of the introduction into this country of the destructive Colorado potato beetle caused such alarm that our first Act of Parliament dealing with the protection of crops was passed, although no special service was inaugurated for the purposes of the Act. Again, the occurrence in 1900 for the first time in this country of the American Gooseberry Mildew, and its rapid and destructive spread throughout the land during the following few years was undoubtedly one of the main causes which led, in 1907, to the passing of the Destructive Insects and Pests Act, which amplified and extended that passed thirty years previously. Moreover, in connection with the 1907 Act a small *ad hoc* inspectorate was inaugurated by the then Board of Agriculture, which has since grown to considerable proportions. Some six years later the Board for the first time appointed an economic entomologist to their own staff, and not long afterwards added a mycologist, thus laying the foundations of the Ministry's present Plant Pathological Laboratory. The Scottish Board added a plant pathologist to the staff of the Royal Botanic Garden, Edinburgh, in 1924, and the Forestry Commission has recently appointed a mycologist. Pathological work in connection with fruit transport and storage is also being carried on now under the auspices of the Department of Scientific and Industrial Research.

An important milestone was reached in 1911, this time in the academic world. This was the foundation at the Imperial College of Science, South Kensington, of a chair in Vegetable Physiology and Pathology, thus indicating an increasing recognition of the importance of the study of plant diseases. Up to the present, unfortunately, this has remained the sole academic chair devoted to plant pathology (apart from its entomological aspects) in this country; but we all rejoiced to learn not long ago that the University of London had conferred the distinction of a professorship on that indefatigable worker Mr E. S. Salmon of Wye College.

The greatest stimulus the development of plant pathology (as well as other branches of agricultural and horticultural science) has received in this country in recent years, however, followed from the provision by the State of greatly increased funds through the Development and Road Improvement Funds Acts, 1909 and 1910, and subsequently through the Corn Production Acts (Repeal) Act of 1921. The importance of developing

research and advisory work in plant pathology, including both diseases and insect pests, was recognised by those charged with the administration of these Acts from the very first; and the present greatly improved position of plant pathology in this country is therefore very largely the result of increased State aid to agriculture, available through the operation of the Development Fund.

For this reason we now have (attached to the Rothamsted Experimental Station) newly erected and lavishly equipped laboratories for unrestricted research in the basic problems of plant pathology. We have plant-disease research work associated with the Universities of Bristol, Cambridge and Wales, as well as with the Experiment Stations for glass-house crops and fruit-growing at Cheshunt and East Malling respectively. This work is carried on by permanent members of the staffs of the institutions in question, by workers provided through the agency of special research grants, or by research scholars. Other phytopathological activities supported by State aid are the Ormskirk Station of the National Institute of Agricultural Botany for the testing of potato varieties for immunity from wart disease, and the Official Seed Testing Station in Cambridge, at which a beginning has recently been made in supplying farmers with information concerning the presence or absence of parasitic fungi on certain kinds of seeds.

In connection with the scheme of increased State aid to agriculture, England and Wales have been divided into fourteen provinces, and in each province, in addition to other advisers, two (a mycologist and an entomologist), have been attached to the staff of the University or College, the Agricultural Department of which is the recognised centre for the province. These officers provide advice for the farmer in their respective subjects, engage in investigations on local phytopathological problems and together form a nucleus for plant-disease and pest survey and intelligence work, the headquarters of which are at the Ministry's Plant Pathological Laboratory in Harpenden.

It is important, however, to note that these developments have not been due solely to State aid, for in some of the cases mentioned this aid has merely been supplementary to substantial financial support from those connected with or interested in the agricultural and horticultural industries. Phytopathological work is also carried on to some extent (unaided by the State) in other ways and at other centres, as for instance at the John Innes Horticultural Institution and at the Wisley gardens of the Royal Horticultural Society, to say nothing of the educational and research work carried on as a normal part of the programmes of some of our Universities and Colleges.

Mention must also be made of the Imperial Bureau of Mycology, founded a few years ago. Although instituted primarily to assist in the development of plant pathology in our Dominions and Colonies and financed entirely by them, this Bureau, directed by our present Vice-President, is also of great service to workers in the Mother Country, both through the excellent monthly abstracts which it publishes and in other ways known to many of you. Nor must the cryptogamic departments of the British Museum and the Royal Botanic Gardens, Kew, be left out of account. For, although their work is perhaps generally regarded as being of a more purely systematic nature, the mycologists there, as we pathologists know well from experience, are frequently a very present help in time of trouble.

Our own Society, also, is by no means forgetful of the assistance which it can render to plant pathology. Its sub-committee has in an advanced state of preparation a standardised list of the common names appropriate for the principal diseases of plants in this country, the publication and adoption of which will, it is hoped, result in the simplification of and uniformity in such nomenclature. Further, much of the time at the winter meetings of the Society is devoted to the reading of papers on, and the discussion of, plant pathological matters, whilst the Society's *Transactions* bear witness to its interest in the subject also. Lastly, the Association of Economic Biologists, both by its meetings and by the publication of papers in its *Annals*, has to an ever-increasing extent in recent years helped to advance plant pathology in this country.

This brief sketch will perhaps enable us to realise something of the position in which plant pathology stands to-day in this country. From it will be gathered, I hope, the main features of present-day *organisation* for the study and practice of plant pathology here; it will show the *machinery* we at present possess for the work. Undoubtedly it represents a very great advance on the facilities, or lack of facilities, which prevailed but comparatively few years ago, although there may be some who, comparing the position here with that in some foreign countries, may still be dissatisfied. High ideals must always carry with them a certain degree of divine discontent. The machinery must be judged by its output or by the work it fails to accomplish. It has been set in motion too recently for us to decide yet whether it is satisfactorily fulfilling its purpose or not. Judged by the numerous papers which have appeared in our various scientific and technical periodicals during the last few years, there is considerable cause for satisfaction, and those of you who would gain some idea of what is being attempted, where State

aid is given, cannot do better than consult the Annual Reports of the Development Commissioners, the last published of which, the sixteenth, covers the year ending March 31st, 1926. Here, of course, will be found not only what is being done in regard to plant diseases, but also what is going on in all the other lines of research and education as applied to agriculture, so that a perspective view of the place of plant pathology amongst the other subjects can be obtained*.

Personally, I am inclined to think the time must come sooner or later when the organisation of plant pathology in this country will require some modification and extension. At present decentralisation appears to be the key to the situation. I, however, should like to see the development, in time, of a strong central institution, not attached as a side-issue to any existing institution, but firmly based on its own foundation and having its own well-defined duties and responsibilities in relation to the agricultural and horticultural industries of this country, with which it would have to maintain intimate contact. At such a centre the staff would comprise not only applied mycologists and entomologists, but also systematists in these subjects. Further, botanists, zoologists, chemists and physicists would contribute their share, to say nothing of physiologists, plant-breeders, bacteriologists and so on. In short, provision should be made, as and when required, for attacking all problems in plant pathology, and these demand for their solution men trained in a considerable number of branches of science. So-called "fundamental" research would not be segregated, for all true research is fundamental. The "applied" lion would have to lie down with the "pure" lamb, or rather the two would waste no time in lying down, but would both be up and doing, the efforts of one supplementing those of the other.

I do not suggest that it is necessarily the duty of the State to provide such an institution, although I am afraid that the industries concerned would find it hard to do so unaided in present circumstances. A private benefactor might do worse than found and endow a Central Institute of Plant Pathology in this country, and such a foundation would ensure the necessary co-operation, concentration and continuity in research and in its practical applications which is not easy of attainment under present conditions. Such a foundation would not necessarily supplant existing agencies, but would rather supplement them.

A feature which may strike an onlooker at the modern developments in plant pathology in this country is that no

* *Research and the Land*, by V. E. Wilkins, published in 1926 by the Ministry of Agriculture and Fisheries subsequent to the delivery of this Address, provides a fuller account.

special effort has been made to train the personnel required, or even to formulate the lines along which training should proceed. Matters have proceeded so rapidly that workers have had to be found in a more or less haphazard way. This was perhaps more or less inevitable at the outset, but there is no reason why the problem, so far as future workers are concerned, should not be tackled.

Mr Brooks, in the Presidential Address to which reference has already been made, offered some suggestions as to the training of mycologists and plant pathologists. With most of his suggestions I am in full agreement, but in one respect I differ from him. He suggests that during the *later* stages of his training the embryo pathologist should be given some familiarity with the growth of crop plants and with crop values. This I admit is better than nothing, but it does not satisfy me. I am convinced that one of the greatest difficulties confronting plant pathology to-day is that much of it is too remote from actual agricultural and horticultural practice. The practitioner does not know nearly enough about his patients, how they grow, what complicated conditions surround the production of crops at a profit, and so on. We are all unfortunately too academic in outlook; and in nine cases out of ten this can never be cured by an attempt to inculcate the right kind of view-point at a late stage of the pathologist's training.

Before a plant pathologist can be trained he must be *recruited*, and in my view he should to a large extent, at any rate, be recruited deliberately from amongst those who understand what agriculture and horticulture really are, because they practise these arts. Select from such sources promising young people with brains, intelligence and zeal. They are as plentiful, proportionately, in these walks of life as in others, but they need careful seeking out. Put them through your more or less academic courses of the various sciences. Their own inherited and acquired instincts will enable them to separate the gold from the dross in these courses, and they will emerge with a knowledge not only of scientific methods, facts and principles, but will be able themselves to determine how best to apply them in actual practice.

It is not, however, my purpose on this occasion to be critical of present arrangements, but rather to show what the existing conditions are in regard to plant pathology in this country, and I return now, in conclusion, to our motto and its application to the plant diseases prevalent here.

For the past nine or ten years a systematic attempt has been made by the pathological department of the Ministry of Agriculture and Fisheries to ascertain exactly what diseases of crops

exist in this country and to what extent their occurrence and intensity vary from year to year. The results of this phytopathological survey have been issued from time to time, the last Report having been published as Miscellaneous Publications No. 52, 1926. It is believed that we now have a fairly complete inventory of the diseases of agricultural and horticultural crops which occur here; the proportion of "notum" to "ignotum"—so far as the existence and names of the diseases are concerned—being therefore very large. In preparing the lists, many members of this Society have rendered valuable service which is greatly appreciated.

But we cannot rest on our oars. We must not remain satisfied with being able merely to diagnose a disease, give it a name and furnish the name of the parasite which causes it—if, as is usually the case, the disease is of a parasitic nature. About many of our diseases—even some of the commonest ones—but little is really known beyond names. If we set as an ideal before ourselves not to be content until we can prevent or cure the various diseases by methods which are not beyond the economic possibilities of practical husbandry, then we shall soon realise how much remains yet to be done. This, after all, and whether we like it or not, is the "acid test" by which our work will be judged by those whom we profess to serve, viz. the growers of crops; and realisation of our present ignorance will, to the keen, enthusiastic worker, act as a stimulant to further effort; only to the indolent will it serve as an excuse for pessimism.

STUDIES IN ENTOMOGENOUS FUNGI.

XIII. GLENOSPORA.

By T. Petch, B.A., B.Sc.

In *Sylloge Fungorum*, IV (1886), 298, Saccardo listed the genus *Glenospora* Berk. & Curt., with the species *Glenospora Curtisii* Berk. & Desm. and *Glenospora ramorum* (Schw.) B. & Br. The descriptions there given are as follows:

"*Glenospora* B. et Curt. North Am. Fungi n. 1002, Sacc. Mich. (Etym. *glene* cavitas v. oculus et *spora*).—Hyphae biogenae, in crustam atram intextae, varie ramosae, septatae. Conidia ramulis diu haerentia, globosa, majuscula, levia.

"*Glenospora Curtisii* Berk. et Desm. North Amer. Fungi n. 1002, Sacc. Mich. II, pag. 147, Fung. ital. tab. 792.—Effusa subcrustacea, aterrima, hispidula; hyphis fertilibus assurgentibus

furcatis v. varie breve ramulosis, parce septatis, fuscis; conidiis perfecte sphaericis 10–12 μ diam., in ramulis subsolitarie acrogenis, guttulatis fuligineo-olivaceis, diu persistentibus. Hab. in cortice subvivo *Magnoliae, Nyssae, Quercus, Cyrillae* etc. in America boreali.

"*Glenospora ramorum* (Schw.) B. et Br. *Rhacodium ramorum* Schw. Carol. n. 1362, *Oedemium ramorum* Fries, Syst. III, p. 345.—Crusta tomentosa tenui 2–3 cm. effusa; hyphis ramosis intricatis diffusis, nigris, tenuibus continuis; fertilibus assurgentibus; conidiis globosis, pedicellatis, minutis, numerosissimis. Hab. in ramulis vivis *Quercuum* et *Andromedae arboreae* in Carolina."

The reference to *Michelia*, II (1880), 147, is to a description of *Glenospora Curtisii* drawn up by Saccardo from specimens on *Magnolia* sent by Ravenel, which is the same as that given in the *Sylloge*. No generic description was included there. The generic description in the *Sylloge* was apparently drawn up by Saccardo later.

The reference to North American Fungi, no. 1002, is to an entry in an instalment of "Notices of North American Fungi" by the Rev. M. J. Berkeley in *Grevillea*, IV (1876), 161, where the genus *Glenospora* and the species *Glenospora Curtisii* were described as follows:

"*Glenospora*. B. & Curt.—Flocci fastigiati fasciculati parce articulati, hic illic sporangia globosa sessilia vel pedicellata ferentibus.

"1002. *Glenospora Curtisii*. B. & Desm.—On *Nyssa, Quercus*, and *Cyrilla*. Car. Inf. No. 2088, 2776, 3059, 3060.

"Forming black hispid patches, consisting of fascicles of fastigiate threads, which bear here and there globose sporangia."

The genus *Glenospora* was, however, instituted several years earlier by Berkeley and Desmazières, in a paper "On some moulds referred by authors to *Fumago*, and on certain allied or analogous forms" (*Journ. Roy. Hort. Soc.* IV (1849), 243–260). In that paper the authors stated:

"We conclude our memoir with the notice of a new genus, which is abundantly produced in certain situations in South Carolina, though the fructification is of rare occurrence. It is generally, if not always, accompanied by a new species of *Myriangium*, but has not the slightest connexion with it. The threads are cylindrical, inarticulate, fasciculate, creeping widely over the matrix of a shining black; giving off branches from the fascicles, which are themselves fasciculate, and often confluent with one another. These are at times contained in a common sheath, exactly as in the genus Microcoleus. They are for the most part barren, but occasionally fructification is produced on

the edge of the fascicles, on the free-branched apices of the threads. It consists of large, globose, dark spores, which contain a single nucleus; from which circumstance we have called it *Glenospora*. It is analogous to *Acremonium*, but that belongs to the group of *Mucedineae*, while this belongs to *Dematia* —resembling closely the mucedinous genus *Brachycarphium*, Berk., discovered in amber by Dr Thomas, and figured in the 'Annals of Natural History' for December, 1848.

"*Glenospora*, Berk. and Desm.

"Hyphasma repens late expansum, floccis fasciculatis supra articulatis communi membranâ vestitis ramosis, prope apices è fasciculis liberatos fructificantibus contextum. Sporae amplae globosae, saepe binae coloratae, nucleo globoso. Analogon *Acremonii* quoad fructum, *Brachycarphii* quoad Hyphasma et apices filamentorum liberatos fructificantes. Vix ulli *Dematiearum* arctè affinis.

"Hab. in corticem *Nyssae aquaticae*, *Aceris rubri*, et *Prini verticillati*, frequens in sylvis humidis et paludibus Carolinae Inferioris, *Myriangii* saepissime si non semper socius.

"*Glenospora Curtisii*, Berk. and Desm. Curt. No. 1442, 1021. (Fig. 11). On the bark of Nyssa aquatica, Prinos verticillata, and Acer rubrum. Extremely common in South Carolina.—Rev. M. A. Curtis.

"It may be remarked, that Mr Thwaites found a very similar production, only with hyaline threads, mixed up with *Coccochloris Brebissonii*, growing in dripping places near Bristol. The fructification and the whole structure are very similar. At present it has not been found by itself, so as to enable him to ascertain its habits and colour when freely developed. The spores are dark-brown, and have a pretty effect on the colourless filaments. This may be called *Glenospora Thwaitesii*, but we have not thought it necessary to give specific characters, as we have scarcely sufficient information for this purpose. The spores of *G. Curtisii*, it may be observed, when viewed by transmitted light, have a lilac tinge, as have also the threads in portions of the stratum, but not constantly."

The characters of *Glenospora* in the description of 1849 do not entirely agree with those of the description of 1876. In particular, the mycelium or stroma was described in the former as repent, while in the latter it was said to be fastigiate, the species, *Glenospora Curtisii*, forming black hispid patches. For *Glenospora Curtisii*, 1849, Berkley cited Curtis 1442, 1021, but for *Glenospora Curtisii*, 1876, he cited Curtis 2088, 2776, 3059, 3060.

As regards *Glenospora ramorum* (Schw.) B. & Br., I have not

been able to find any reference to that name by Berkeley and Broome. In Broome's interleaved copy of Hoffmann, *Index Mycologicus*, now in the British Museum, he has entered "*Glenospora ramorum* B. & C., F.C. exsicc. I. 87." The latter reference is to Ravenel's Fungi Carolinae Exsiccati, in which no. 87 of century 1 is labelled "*Glenospora ramorum* Berk. & Curt. *G. Curtisii* Berk. & Desm. *Dematium ramorum* Schwein. Cortice viv. Nyssae." Broome, therefore, did not claim any authorship of *Glenospora ramorum*.

Saccardo gave, as synonyms of *Glenospora ramorum*, *Rhacodium ramorum* Schw., Carol. no. 1362, and *Oedemium ramorum* Fries, *Syst.* III, 345. Fries (*loc. cit.*) described *Oedemium ramorum*, with the synonym *Racodium ramorum* Schwein. Car. n. 1362, as "Fibrae contiguae, opacae, nigrae, tenues, parce ramosae, crustam tenuem tomentosam ad 4 unc. usque expansum sistunt; fertiles surgunt. Sporae e latere floccorum breviter, at evidenter pedicellatae, quare secedentes appendiculatae, opacae, nigrae, exacte globosae, in aqua vero secernentes sporidia minuta, numerosissima, globosae, pellucida, quibus evacuatis sporae membranaceae pellucidae. A praecedente [O. atrum] differt ut *Mycogone* a *Sepedonio*, sed si tam subtiliter genera distinguimus, singula genuina species peculiare genus. Ad ramos vivos *Quercuum* et *Andromedae arboreae* in Carolina (v.s.)."

Fries' description of *Oedemium ramorum* was drawn up from a specimen of "*Racodium ramorum* Schwein.," but the collector's name is not stated. Saccardo's description of *Glenospora ramorum* is evidently based on that of Fries, though the length, 4 inches, in the latter becomes 2–3 cm. in the transcription.

A search through Schweinitz's lists, however, has failed to reveal any species, *Racodium ramorum*. *Synopsis fungorum Carolinae superioris*, no. 1362, cited by Fries, is *Racodium ramosum* Schwein., described as "R. cohaerens hinc inde floccosum nigrum tenue, filis subramosis distinctis. Ramos vivos quercinos et Andromedae arboreae undique investit, quatuor fere uncias latum. Affine rupestri." Similarly, the name *Dematium ramorum* Schwein., cited by Ravenel, does not appear to have been published by Schweinitz.

It will be noted that in Fungi Carol. Exsicc. 1, 87, Ravenel regarded *Glenospora ramorum* B. & C. as synonymous with *G. Curtisii* Berk. & Desm. A specimen in Herb. British Museum may, perhaps, throw some light on this. It is labelled in Curtis's script, "*Glenospora ramorum* M.A.C. *Glenospora Curtisii* Berk. & Desm. in ramul. viv. Nyssae. Carol. Septentr. M.A.C." To that is added a printed label "coll. M. A. Curtis. Distrib. W. G. Farlow," and a manuscript label, "*Glenospora Curtisii*" by Farlow.

It would appear that *Glenospora ramorum* was Curtis's name for the species which Berkeley and Desmazières described as *Glenospora Curtisii*, but the former name was not published. I have not seen any evidence that Curtis considered this species identical with *Racodium ramosum* Schw., though it is quite probable, from the description of the latter, that it is.

Ravenel distributed Fungi Carol. Exsicc. 1, 87 as *Glenospora ramorum* B. & C., but in his Fungi Americani Exsicc., no. 333, nearly thirty years later, he issued the same species as *Glenospora Curtisii* B. Again, Herb. British Museum purchased Ravenel's herbarium in 1891, but none of the specimens so obtained is indisputably labelled *Glenospora ramorum*. These specimens are as follows:

(A) "113. *Glenospora Curtisii* B. on *Carpinus*. Gainesville, Fla. H. W. R." in Ravenel's writing.

(B) "Ravenel, Fungi Americani Exsiccati, no. 333. *Glenospora Curtisii* B. in cortice Nyssae et Carpini, Darien, Georgia": and an unnumbered duplicate, both with printed label.

(C) "*Glenospora ramorum* B. & C. *G. Curtisii* B. & Desm. Aiken. S. C. Cortice Nyssae. H. W. R." in Ravenel's writing. Subsequently Ravenel crossed out "*ramorum*" and substituted *Curtisii*, deleting also the C. of "B. & C." This specimen is probably a duplicate of "Fungi Exsiccati selecti ex herb. M. C. Cooke. *Glenosporium* (sic) *ramorum* B. & C., on *Nyssa*, Aiken, S. C. Ravenel," four copies of which are in Herb. Kew.

(D) "1195. *Glennospora Curtisii* Berk. & Desm. *Glennospora ramorum* Berk. & Desm. Hieme. Ramulis Nyssae. S. C. H.W.R." in Ravenel's writing.

(E) "3207. *Glennospora ramorum* Berk., on living *Myrica cerifera*. Darien, Ga. March 81. H. W. R." in Ravenel's writing, the name being in pencil and having "*Curtisii*" written over "*ramorum*." In Herb. Kew, there is a duplicate of this, marked by Ravenel, "Looks like *Glenospora Curtisii* Berk. March, 1881, on living *Myrica cerifera*. Darien, Ga. H. W. R. never saw the species on *Myrica*."

The evidence of these specimens from Ravenel's herbarium favours the supposition that Ravenel used first the name *Glenospora ramorum* and later *Glenospora Curtisii* for the same species.

Both Herb. Kew and Herb. British Museum have copies of Ravenel, Fungi Carol. Exsicc. 1, 87, *Glenospora ramorum* B. & C.; Ravenel, Fungi Americani Exsicc., no. 333, *Glenospora Curtisii*; and Thuemen, Mycotheca universalis, 292, *Glenospora ramorum* Berk. & Curt. (coll. J. B. Ellis).

Herb. Kew has also "*Glenospora Curtisii*. N. Jersey. in cort.

viv. Nyssa" in Berkeley's handwriting; Curtis 2088, 2776, 3059, 3060; a specimen numbered 4051 (in pencil), marked by Ellis, "I think this ought to be *Glenospora melioloides* B. & C., but have no specimen for comparison," and stamped "Herb. Mycol. M. C. Cooke. 1885"; a duplicate from Ellis of Thuemen 292; "*Glenospora Curtisii* B. & Desm. ram. viv. Nyssae. Carolina," in Curtis's script, *ex* Herb. Cooke; "*Glenospora ramorum* B. & C. *forma*. Aiken. S. Car." written by Cooke on his usual small envelope; "*Glenospora Curtisii* B. & C. Florida. Rav." written by Cooke on small envelope.

Whether labelled *Glenospora Curtisii* or *Glenospora ramorum*, all but three of these specimens are the same species. The exceptions are Curtis 2088, Ellis 4051, and Cooke's "*Glenospora ramorum* B. & C. *forma*."

The type specimens of *Glenospora Curtisii* Berk. & Desm., 1849, are Curtis 1442 on *Prinos verticillatus* and Curtis 1021 on *Acer rubrum*. Berkeley's record of *Nyssa* as a host plant in 1849 was based on Curtis's statement (MS.) that the fungus was common on *Nyssa*. Unfortunately neither 1442 nor 1021 is in Herb. Kew or Herb. B.M.

In his description published in 1849, Berkeley stated that *Glenospora Curtisii* was generally, if not always, accompanied by a new species of *Myriangium*. The latter was *Myriangium Curtisii*. Berkeley sent specimens of this *Myriangium* to Montagne, and one of these was Curtis 1442, which is now in Herb. Montagne in Herb. Paris, among the lichens *sub Myriangium Curtisii*. Montagne returned to Berkeley a drawing of the *Myriangium* and another of the *Glenospora*, the latter inscribed "Mucédinée du Myriangium." These drawings are now in Herb. Kew.

Berkeley also sent specimens of this *Glenospora Curtisii* to Thwaites (at Bristol). Dr C. H. Gadd has kindly searched the collection of fungi which Thwaites took out to Ceylon shortly afterwards, and informs me that it does not contain this species.

Consequently, as far as is known at present, the only specimens of Curtis 1442 in European herbaria are in Herb. Montagne in Herb. Paris. One of these is included among the lichens *sub Myriangium Curtisii*; it contains the *Myriangium*, with scanty remains of a *Glenospora*, which are wholly repent. Montagne detached almost the whole of the *Glenospora* and included it in his herbarium under that name. The latter specimen is marked "no. 1442 *Glenospora* Berk. cum *Myriangie Curtisii*. Carol. Sup. Berk.," and consists of a few very small fragments, mounted on a sheet of mica; it includes a minute stroma of the *Myriangium*, and several fragments of the *Glenospora*, which, as far as can be determined, were wholly repent. Montagne's figures

show repent mycelium only, and are inscribed "Mucédinée qui accompagne sous forme de mycelium le *Myriangium* de la Caroline Super. Berkeley. *Glenospora* Berk. Sporae lilacinae, primo hyalinae."

Berkeley found that in the specimens which he first received from Curtis, *Glenospora Curtisii* occurred in company with *Myriangium*. That association, however, does not appear to occur frequently. Of all the specimens of *Glenospora* and *Myriangium* in Herb. B.M. and Herb. Kew, there is only one, viz. Ravenel, Fungi Americani Exsiccati, no. 332, in which both fungi are present. The reason for this association is that both the *Myriangium* and the *Glenospora* are parasitic on scale insects.

From Berkeley's original description (1849) and Montagne's specimens of Curtis 1442, it is clear that the *Glenospora Curtisii* of that date was indentical with the majority of the specimens which have since been issued under that name and under the name *Glenospora ramorum*. The fungus forms a thin, black film or crust, over-running scale insects on living branches. The film is composed of thick-walled, septate hyphae 3–4 μ diameter, sometimes irregularly flexuose and intertwined, sometimes united laterally into strands. The hyphae are blackish brown, becoming hyaline or lilac-grey at the apex, and merge here and there into an amorphous hyaline sheet. In some examples, at the margin of the stroma, the repent mycelium forms a series of stars, with curved rays up to 20 μ broad which branch and anastomose and frequently give off separate hyphae laterally. These rays are black and shining and consist of hyphae fused laterally to one another. Ladder connections occur between the hyphae of these strands. Further back, the strands have branched, or have given off single hyphae, until at first a network, and finally a continuous sheet, is produced.

There is no sheath round the strands, but their margins may be bordered by a hyaline or pale brown amorphous film, and a film of the same character may fill the meshes of the network.

The hyphae bear globose, spore-like bodies laterally, either on very short pedicels or on short lateral branches. These occur on hyphae which run singly, or diverge from the strands. They may occur singly, or several on the same branch. A lateral branch 20 μ long in one instance bore three of these bodies, one terminal and the other two alternate and equally spaced. Another branch, of about the same length, bore five, two opposite pairs and one terminal, forming a series in contact. Sometimes two, sometimes three of these pseudo-conidia occur at the apex of a lateral branch. They are globose, moderately thick-walled, smooth, at first lilac, then blackish brown.

Measurements on different specimens gave a diameter of 7–9 or 8–12 μ. The "single nucleus" described and figured by Berkeley was not evident on the spores examined.

The specimens which appear to differ from *Glenospora Curtisii* Berk. & Desm. are Curtis 2088, Ellis 4051, and Cooke's "*Glenospora ramorum* B. & C. forma. Aiken S. Car." Unfortunately, Curtis 2088 is the type specimen of the *Glenospora Curtisii* B. & C. of 1876.

In the specimen Curtis 2088 in Herb. Kew, the fungus forms a black hispid patch. It consists of a thin basal layer, from which arise close-set, somewhat rigid fascicles of hyphae. The basal layer is composed of branched, irregularly flexuose and intertwined, thick-walled hyphae, about 3 μ diameter, varying in colour from blackish brown to hyaline, the hyphae merging here and there into a hyaline amorphous sheet. The erect fascicles are up to 1·8 mm. high, and 0·1 mm. in diameter below, tapering upwards to a subacute apex, and are composed of hyphae similar to those of the basal layer, but regular. These hyphae are firmly united to one another laterally, and occasionally two or three fascicles fuse into one at a short distance from the base. Some of the hyphae of the fascicles are beaded with narrow-oval swellings at close intervals. I did not find globose conidia in this specimen.

Ellis 4051 is similar to Curtis 2088, but the beaded hyphae were not observed in it. Globose conidia were not found.

The specimen, "*Glenospora ramorum* B. & C. *forma*" from Cooke's herbarium is a thin, black film, from which arise widely scattered groups, each of a few erect bristles. The black film is similar to that of *Glenospora Curtisii* and contains globose conidia. The erect fascicles are shorter than in Ellis 4051, but of the same structure; they bear a few globose conidia, more especially on loose hyphae near the base.

It is possible that the last specimen may be *Glenospora Curtisii*, in which case that species can produce erect fascicles. But Curtis 2088 and Ellis 4051, which have no globose conidia, are more probably another species.

The globose bodies do not become detached and are probably not conidia. It would appear more probable that the specimens should be referred to *Septobasidium*, and that the globose bodies are probasidia. Curtis 2088 may be parallel to *Septobasidium pteruloides* (Mont.) Pat. (*Lachnocladium rameale* B. & Br.). These points, however, can be determined only by further investigations in the type locality.

The various species which have been referred to *Glenospora* in medical mycology do not appear, from the descriptions, to belong to that genus.

Mr J. Ramsbottom, of the British Museum, has given me the full benefit of his wide knowledge of the collections and memoranda in that herbarium during the preparation of this paper, and I desire to record my sincere thanks for his valuable assistance.

Conclusions.

The genus *Glenospora* was established by Berkeley and Desmazières in 1849, not by Berkeley and Curtis in 1876.

Glenospora ramorum was first published by Ravenel in Fungi Carol. Exsicc. I, 87, and was Curtis's name for *Glenospora Curtisii*.

Berkeley's *Glenospora Curtisii* of 1876 is not the same species as his *Glenospora Curtisii* of 1849, in so far as the first specimen (Curtis 2088) cited by him for the former is concerned.

The genus *Glenospora* is probably to be referred to *Septobasidium*.

OBSERVATIONS ON SOME SCOTTISH UREDINEAE AND USTILAGINEAE. II*.

By Malcolm Wilson, D.Sc., F.R.S.E., F.L.S., Reader in Mycology, University of Edinburgh, and J. S. L. Waldie, B.Sc., C.D.A., Assistant in Mycology.

Puccinia le Monnieriana Maire.

Teleutospores on *Cnicus palustris* Hoffm. Drumlanrig near Thornhill, Dumfriesshire, September, 1924.

Teleutospore sori hypophyllous, seated on slightly depressed yellowish spots about 2–4 mm. in diameter, in small irregular dense groups about 2–3 mm. wide, often confluent, pulvinate, surrounded by the ruptured epidermis, dark brown; teleutospores clavate, apex rounded, truncate or acutely conical, strongly thickened (8–14 μ), constricted at the septum, rounded or often attenuate at the base, smooth, yellowish brown, 40–55 × 14–21 μ; pedicels hyaline or brownish near the apex, thick (6–8 μ), persistent, up to 65 μ long.

This species was first found by Maire (*Bull. Soc. Mycol. France*, XVI (1900), 65) near Luneville, France, and has also been recorded from Portugal. Only teleutospores have been found and this appears to be the only spore-form. The groups of sori occur only on the under surface of the leaf, those near the margin

* The first paper dealing with the subject appeared in *Trans. Brit. Mycol. Soc.* IX (1924), 135.

being irregularly grouped while those nearer the mid-rib are often somewhat circinately arranged. The sori are strongly pulvinate and form compact masses. According to Maire the spots are bordered with violet, but this was not observed in our specimens.

This species differs from all others found on the genus *Cnicus* by the very strongly thickened wall at the apex of the spore, being most nearly approached in this character by *P. Cnici-oleracei* Pers. It is distinguished from this species by the smaller, often confluent, sori, and by the more strongly thickened, usually pointed, teleutospores.

Maire also records the rust in September and it appears to be a species developing in the autumn. The specimens were found during the excursion of the Scottish Cryptogamic Society, on plants growing in a damp mixed wood, and the species was recorded in their annual report for 1924.

UROMYCES SPARSUS Lév.

Uredospores and teleutospores on *Spergularia marginata* Kittel (*S. media* Pers). Collected by Mr J. K. Leven near Longniddry, Haddington, June, 1925.

The sori are present on the stems, leaves and sepals. This species has been recorded from Kent on *S. rubra* but is apparently very rare in England. It has not been previously recorded from Scotland.

MELAMPSORELLA CARYOPHYLLACEARUM Schroet.

Uredospores on *Cerastium arcticum* Lange. Collected by Mr R. J. Pealling, Ben Nevis, August, 1924.

Not previously recorded on this host. *Cerastium arcticum* is not found at lower than about 2500 ft. and no species of *Abies* are present in the vicinity at anything approaching this altitude. It is difficult to understand, in this case, how *Abies* sp. can function as the alternate host.

CRONARTIUM RIBICOLA Fisch. de Waldh.

Aecidia on *Pinus parviflora* Sieb. & Zucc., Murthly, Perthshire, June, 1924.

Not previously recorded on this host in Britain.

AECIDIUM IMPORTATUM P. Henn.

On leaves and petioles of *Peltandra virginica* (L.) Kunth. Royal Botanic Garden, Edinburgh, June, 1924.

This was described by Hennings in 1895 (*Verh. Bot. Ver. Prov. Brand.* XXXVII (1895), pp. XXV and 12) who found it in the Berlin Botanic Garden on plants imported from North America.

The spermogonia appear first in June on the petioles and

under side of the mid-rib of the leaf. They are conical and reddish brown in colour. The aecidia appear in July in the same positions. They are at first hemispherical and orange-yellow and remain long closed, becoming almost cylindrical before opening. After the orange aecidiospores are shed the pseudoperidium persists as a white structure.

Spores 25–30 × 20–27 μ, spherical or elliptical, often angular.

There is an abundant colourless mycelium in the mid-rib and petiole. The mycelium persists in the root stock and produces the aecidia each year in the early summer, the leaves formed later not being attacked. The host plant does not appear to suffer at all from the presence of the fungus. *Aecidium importatum* Henn. is not known from North America. *Aecidium Caladii* Schw. (*Uromyces Caladii* Farl.) is regarded by Arthur (*North American Flora*, VII (1912), 236) as co-specific with the form on *Peltandra virginica*, i.e. *Uromyces Ari-Virginici* Howe.

The origin of the plants at Edinburgh is not known, but it is unlikely that they were obtained from Berlin. They have been producing the aecidia for several years and were probably infected when introduced into the garden.

Uredo Glyceriae Lind.

On *Glyceria maritima* R. Br. Collected by Miss M. M. B. Knagg, near Linlithgow, Firth of Forth, May, 1925.

Sori epiphyllous, scattered, rounded-elliptic or elongated, up to 1 mm. long, surrounded by the ruptured epidermis, yellow; paraphyses numerous, clavate-capitate, 50–60 μ long 14–18 μ wide at the apex, hyaline or pale yellow above, membrane up to 2 μ thick; uredospores globose, ovate or ellipsoid, verrucose-echinulate, subhyaline or yellow, 24–30 × 20–25 μ, epispore 1–1·5 μ thick, with 8–10 scattered germ pores.

The above description is copied from Sydow (*Monographia Uredinearum*, IV (1924), 540) and Lind (*Danish Fungi*, p. 343). In the Scottish specimens the spores are slightly smaller than described above, but in other respects the specimen agrees closely with the description. The species has been previously recorded only from Denmark.

Urocystis Anemones (Pers.) Schroet.

On the petioles of *Ranunculus Ficaria* L. near Edinburgh, May, 1924, and on the stems and leaves of *Trollius europaeus* L. near Lochranza, Isle of Arran, July, 1926.

The forms on *R. Ficaria* and *T. europaeus* do not appear to have been previously recorded in Britain. Trail (*The Scottish Naturalist*, IV (1889–90), 370) lists *U. Anemones* as occurring on *Anemone nemorosa* L. and *Ranunculus repens* L. in Scotland

and in foreign countries it has also been recorded on several other hosts. Sydow (*Oesterr. botan. Zeitschr.* I (1901), 12) recorded the occurrence of this smut on *Trollius europaeus* in the Tyrol. On *Trollius* the spore balls consist of two or three thick-walled spores surrounded by a number of very regularly arranged sterile cells, while on *Ranunculus Ficaria* the thick-walled spores are usually three or more in number. In colour and in structure the spores agree with the description of those of *Urocystis anemones* given by Saccardo (*Sylloge Fungorum*, VII (1888) 518). On *Trollius* the spore balls measured 25–35 μ, while the spores were 15–18 μ.

STUDIES ON RHIZOCTONIA CROCORUM (PERS.) DC. AND HELICOBASIDIUM PURPUREUM (TUL.) PAT.*

(With Plates XI–XIV.)

By W. Buddin and E. M. Wakefield.

THE present paper is the outcome of observations and experiments made during the past three years with the object of elucidating, if possible, the life history of the fungus *Rhizoctonia Crocorum* (Pers.) DC. Owing to unexpected difficulties and complications which developed in the course of the cultural work, the results obtained up to the present can only be regarded as preliminary, and are not put forward with any claim to finality. As, however, for various reasons it seems unlikely that any more conclusive results will be obtained by the authors for some time, this account of what has been done is published in the hope that it may be of service to other workers.

The investigation arose out of an identification made in the autumn of 1922. At that time there was received at Kew from the Horticultural Research Station at Long Ashton a stump of black currant (*Ribes nigrum*) which had a dense felted violet growth round the main stem. The growth was sterile, but from previous knowledge of the habit and structure of *Helicobasidium purpureum* (Tul.) Pat. little hesitation was felt in suggesting that it was probably this species. Subsequently, however, it was found that the roots of the *Ribes* showed the bodies known variously as microsclerotia, or better as "infection cushions"

* Paper read at the International Congress of Plant Sciences, Ithaca, N.Y., August 19th, 1926.

or "corps miliaires," which are characteristic of attack by *Rhizoctonia Crocorum*. The question then arose as to whether the first identification had been an error, or whether *Helicobasidium purpureum* could conceivably be the long-sought-for perfect stage of the *Rhizoctonia*.

A priori the latter suggestion seemed to be more feasible than some of those which had been advanced at various times. *Helicobasidium* is a Basidiomycete, to which group the fructification of *Rhizoctonia* would most probably belong. Further, one species, *Helicobasidium Mompa*, is known to be a root-parasite of the mulberry in Japan, and to produce sclerotia on the roots; while another species, *H. longisporum* Wakef., occurred in association with a *Rhizoctonia*-like mycelium on roots of cacao in Uganda, and was suspected of parasitism.

Rhizoctonia Crocorum has long been known in the sterile state as a root parasite of numerous plants, and from time to time various suggestions have been made as to its mode of reproduction. A complete summary of the literature on the subject was given by Duggar (1) in 1915, and his paper should be consulted for further details. The two suggestions which have received most attention are those of Fuckel and Eriksson. The former (2) found a Pyrenomycete, *Leptosphaeria circinans* (Fuck.) Sacc., associated with *Rhizoctonia* on roots of lucerne, and suggested a connection between the two fungi. The same association has also been noticed by other observers. Duggar, however, germinated spores of *Leptosphaeria circinans* and obtained from them a mycelium which had no resemblance to that of *Rhizoctonia*. Eriksson, no doubt influenced by the discovery that the perfect stage of *Rhizoctonia Solani* is a *Corticium* (or *Hypochnus*, as it was first called), examined some material, preserved in spirit thirteen years before, of certain weeds which had been planted in soil inoculated with *Rhizoctonia Crocorum* from carrots. As a result he announced that he had found a *Hypochnus* which he believed to be the perfect stage of the *Rhizoctonia*, and he gave to it the name *Hypochnus violaceus* (3)*. Unfortunately he gave no description whatever of his supposed *Hypochnus*. It is to be noted that he claimed to have found only *basidiospores*, and possibly did not see basidia. In the absence of any confirmatory evidence it has not been possible to accept Eriksson's conclusion.

In a subsequent paper (4) Eriksson used his supposed discovery of a *Hypochnus* stage connected with *Rhizoctonia* on carrot as

* In the 3rd edition, 1926, of Delacroix and Maublanc, *Maladies des Plantes Cultivées*, p. 144, the new combination *Corticium Erikssonii* is used for this supposed perfect stage. As Eriksson's name was a *nomen nudum*, the change is superfluous.

an argument in favour of the view that the Rhizoctonias of carrot and lucerne are distinct, since he had already concluded that the latter was connected with *Leptosphaeria circinans*. He further suggested that the *Rhizoctonia* found on asparagus might be yet a third species and possibly connected with *Diaporthe* (or *Leptosphaeria*) *Asparagi* Fuck. The present authors (5) have already shown that cross-inoculations lend no support to this idea. In 1923 and 1924 they were able to produce typical root-rot in carrots with pure cultures of *Rhizoctonia* isolated from red clover, and since that time they have carried out successful inoculations on various leguminous plants, including lucerne, with strains of *Rhizoctonia* derived from sugar beet, from potato, and from mangold.

Obviously all these speculations as to the connection of associated spore-forms were without experimental proof. This was no doubt partly due to the failure of all the early attempts to grow *Rhizoctonia Crocorum* in pure culture. This difficulty was finally overcome by Van der Lek (6) who, in 1917, succeeded in obtaining pure cultures on malt agar. He did not, however, pursue the work, and his cultures have been allowed to die out.

Not wishing to add yet another unproven guess to an already somewhat formidable list, we determined to test our *Helicobasidium* hypothesis, if possible, by means of pure cultures and inoculations, and to that end set out to obtain material for experiment. Fortunately, just at the time excellent material of *Rhizoctonia* on red clover was received from Mr W. M. Ware, who kindly responded to a request to supply relays of specimens. The successful starting of pure cultures has already been recorded (5). It may be mentioned here that by the methods described in that paper successful isolations of undoubted *Rhizoctonia Crocorum* from various plants have since been made.

Field Observations.

The problem of obtaining fresh material of fertile *Helicobasidium* for the purpose of making cultures for comparison seemed much less likely to be readily solved. The fungus had apparently been found only once in this country, namely at Alresford, Hants, on ash bark. As the species is more often recorded in France, an effort was made to obtain fresh specimens from mycologists there, but without success. Again, however, a fortunate coincidence occurred. Hearing that Mr Ware, who had been continuing his work on the clover disease (7), had found an associated spore form, the authors wrote explaining what they wanted, and inquired whether by chance Mr Ware's fungus might be this species. Mr Ware at once sent drawings and specimens, which the authors were delighted to recognise

as their much wanted *Helicobasidium*. They would like to take this opportunity of expressing their appreciation of the great generosity and helpfulness of both Professor Salmon and Mr Ware, who handed over all their material of the fungus.

(1) On April 30th, 1923, the senior author visited Wye, and in company with Mr Ware examined the field of red clover where both *Rhizoctonia* and *Helicobasidium* had occurred. *Helicobasidium* was found in small areas here and there through the field. It was difficult to see on account of the tall growth made by the clover by this time, but sometimes it was possible to pick out a likely spot by the somewhat sickly yellowish appearance of the plants. The fungus occurred close to the ground, surrounding the bases of the clover stems and the lower leaf-sheaths, and spreading outwards from them to surrounding objects, as oat stubble, grass, stones, soil, etc. Numerous clover plants showing the fungus were dug up and taken away with the surrounding soil intact. The following day the soil was carefully washed away, and in many cases the *Helicobasidium* was found to be associated with plants which showed typical root-rot due to *Rhizoctonia Crocorum* (Plate XIII, fig. 32). The association was so close and the colour of the mycelium of both so similar, that connection seemed most probable, although it was not possible actually to trace the fine hyphal strands continuously from the infection cushions to the fertile *Helicobasidium*. In most of the affected plants the root-rot had proceeded so far that the dead cortex slipped off easily, and frequently only a stump of the tap-root remained. Further, at such a late stage the filamentous mycelium of the *Rhizoctonia* is less evident than in the early stages of disease, and it was sometimes difficult to find any external hyphae running along the diseased roots.

(2) On October 13th, 1924, Miss J. C. Eyre sent a small box of resupinate fungi collected at Ipplepen, near Newton Abbot, Devon. Amongst them was what appeared to be *Helicobasidium purpureum*, though as yet sterile, growing on ash bark and on some small green stems. Miss Eyre fortunately was able to find again the spot whence it came, and in company with her the senior author thoroughly examined the locality about ten days later. The fungus was completely covering a thick ash root which had become exposed just inside a rabbit burrow. Some of the finer roots which were hanging round the mouth of the burrow were also covered with the same beautiful violet felt, while within an area of about a square yard the fungus occurred also on dead twigs and leaves and sometimes attached to the base of the stems of Dog's Mercury (*Mercurialis perennis*), which was practically the sole ground vegetation at that spot.

After a careful preliminary survey it was decided to leave the large mass of mycelium on the ash root undisturbed, in the hope of obtaining spores later. Digging was undertaken round about in order to excavate any other roots that might be harbouring *Rhizoctonia*. Some fine ash roots, an ash seedling, and numerous plants of *Mercurialis* that were in contact with the aerial felt were thus removed and taken away for more detailed examination. After washing to remove the soil, all the fine ash roots, and also the root of the ash seedling, were found to be invested with either fine strands or even fairly thick cords of deep, reddish purple mycelium, running backwards from the aerial felt. In none of the ash roots however were any infection cushions observed.

The *Mercurialis* provided more definite information. Similar strands of the purplish mycelium were found running along the stolons from plant to plant, and in one case were clearly seen to be connected with the purplish felt on an ash twig which had been lying on the surface of the ground beside the plant. Of greatest interest was the fact that this plant, and also many others of *Mercurialis* dug up from the area infested by the fungus, showed dark decayed roots and stolons from which the cortex came away easily. With the aid of a lens, numerous bodies resembling "corps miliaires" were detected on these decayed roots and underground stems, and that this was in reality their nature was confirmed subsequently by microscopic examination. The "corps miliaires" or infection cushions of *Mercurialis* agree exactly in structure with those found on potato, clover, etc., affected with Violet Root Rot, but are slightly larger than those on clover with which they were compared. Plate XIV, figs. 33 and 34, shows a plant of *Mercurialis perennis*, with diseased roots and stolons, the mycelium from which is connected with encrusting mycelium on the adjacent debris. Attempts to isolate the fungus from the roots failed in this case, owing to the fact that they were too badly rotted and consequently contaminated with other more rapidly growing organisms. Fig. 34 shows a typical example of a rotted stolon, with cortex becoming detached, and numerous infection cushions.

Miss Eyre kindly undertook to keep the locality under observation. Investigation of all available records of *Helicobasidium* had indicated that the fructification occurs apparently only in spring. It was hoped therefore that the large mat of mycelium which had been left intact on the ash root would produce spores in the following spring months and thus establish another case of close association of *Helicobasidium* and *Rhizoctonia*. Climatic conditions during the winter were unfavourable, and by April,

1925, only a collapsed brownish membrane was apparent. Fortunately, however, satisfactory evidence has since been obtained. At the beginning of March of the present year (1926) Miss Eyre reported that fresh violet mycelium was appearing again in the same spot, both on the large ash root and on the smaller plants around. Towards the end of March, with the onset of warmer weather, she was successful in finding the fertile *Helicobasidium* hymenium on the aerial felt, and forwarded specimens for confirmation. Examination of these showed that the hymenium had formed sometimes above the old collapsed mycelial weft, and was growing from it, so that there could be no doubt of the continuity of this sporing stage with the mycelium previously observed. In other cases the fructification was not obviously connected with any old mycelial felt.

(3) On April 10th, 1925, Miss Eyre found good fertile specimens of *Helicobasidium* in another locality, and forwarded material for examination. A week later this ground was carefully examined and digging operations undertaken.

Here the *Helicobasidium* occurred on a low hedge-bank which divided a narrow lane from a field. In a small area, a square yard or less, it was found in abundance, encrusting the bases of various plants growing there, notably *Urtica dioica*, *Digitalis purpurea*, and occasionally small grasses. It occurred also on the bare soil just inside a rabbit burrow*. Examples of all the plants with which the fungus was associated were carefully uprooted and taken away for examination. After the roots had been washed free from soil it was found that those of *Digitalis* and the grasses were perfectly clean and healthy. In the *Urtica*, however, unmistakable root-rot was present, again with infection cushions such as are typical of *Rhizoctonia Crocorum*. Plate XIV, fig. 35, shows an example of *Urtica* with the fructification of *Helicobasidium* at the base of the stem, while the roots and runners bear the infection cushions of *Rhizoctonia*.

The original diagnosis of the fungus on black currant as *Helicobasidium purpureum*, made before its association with *Rhizoctonia* on the roots of the same plant had been observed, has thus been justified. On three further hosts, and in three widely separated localities, there has been found close association of the Basidiomycete with root-rot having the characters of attack by *Rhizoctonia Crocorum*.

* A similar frequent production of the fructification in holes in the ground occurs in the fungus causing Texas root-rot of cotton, *Phymatotrichum omnivorum* (Shear) Duggar. In both fungi the requirements for the production of spores appear to be shade and a humid atmosphere. (See King, C. J., in *Journ. Agr. Res.* XXVI, 1923, p. 407.)

Nomenclature and Description of the fungus *Helicobasidium purpureum*.

The basidiomycetous fungus in question was first described and figured by Tulasne (8, 9) under the name *Hypochnus purpureus*. His description of its habitat, at the foot of small trees or covering living and dead parts of small herbaceous plants, its distinctive violet colour, and his excellent figures of the basidia and spores leave no doubt as to the fungus he had before him.

In 1885 Patouillard (10), having apparently overlooked Tulasne's work, described the species as new and created for it the genus *Helicobasidium*, characterised by the peculiar curved, septate basidia. Fortunately he used the same specific name, *purpureum*, so that no change was necessary when the identity with Tulasne's fungus was recognised. In a later work Patouillard himself cited *H. purpureus* Tul. as a synonym of his *Helicobasidium purpureum* (*Essai Taxon.*, 1900, p. 12). Meanwhile Schroeter (11) had founded the genus *Stypinella* on Tulasne's species; his genus was, however, antedated by Patouillard's and cannot stand.

Helicobasidium purpureum (Tul.) Pat. has been recorded in Europe from several districts of France, from Germany, and at the time the present work was begun once only from England. It has not yet been found in America, but *Helicobasidium Peckii* Burt, founded on an old collection from the Adirondack Mountains, seems to be very closely allied, differing mainly in the colour, in which no trace of violet is mentioned. As the colour of old dried specimens of *H. purpureum* is frequently hardly violet, but cinnamon-drab*, it seems possible that *H. Peckii* may prove to be the same species.

H. purpureum occurs sometimes on bark at the base of trees, on fallen branches, leaf debris, etc., but more often it is found encrusting the bases of small herbaceous plants, after the manner of *Sebacina incrustans* Tul. It is usually found to be quite separable from its above-ground support, and for this reason Bourdot, when describing it in his "Hyménomycètes de France" (*Bull. Soc. Myc. Fr.* XXV, 1909, p. 17), added "il n'est point parasite." It is interesting, however, to note that in the description accompanying Roumeguère's Fungi Gallici Exsiccati, No. 3706 (*Rev. Myc.* 1886, p. 146), evidently compiled from notes made by Barla, it is stated that the fungus sometimes covers a great extent of its support, and envelopes the whole root-system of the plant, which it soon destroys. This

* The colour-terms used throughout this paper are those of Ridgway, *Color Standards and Color Nomenclature*.

particular collection, made by Barla in the neighbourhood of Nice, was described as having a conidial form, which, according to Patouillard (12), occurred in March, before the basidia appeared. The statement is particularly interesting in view of the fact that a conidial fungus, to be described later, has frequently occurred in cultures made by the writers, although so far it has not been seen in nature. The odour of lighting gas, which was attributed to Barla's fungus, has not been noticed in any British specimens of *Helicobasidium*.

As far as available records and the writers' experience show, *H. purpureum* occurs in fertile condition during only a very limited period of the year, roughly from the end of March till the latter part of May, and even then is doubtless dependent on the occurrence of favourable climatic conditions. It is at its best in very mild, moist weather such as occurs in the south of England about April, and it is extremely sensitive to hot sun or drying winds. When growing at the base of closely-set herbaceous plants such as clover, or in a shady wood, it appears to find its ideal conditions.

The fructification consists of an indefinitely effused, fairly thick, dense felt, not at all gelatinous or waxy, of a beautiful purplish or violet colour when at its best. The exact colour varies from light greyish-vinaceous, through livid brown and deep purplish-vinaceous, to dark Corinthian purple. The growing margin is byssoid and paler, while the hymenium is smooth, close but not waxy, and pruinose from the abundant hyaline spores and projecting sterigmata. With age, or in dry weather, the whole fungus becomes much paler in colour, tends to lose the purple tinge, and acquires a cinnamon-drab hue.

The basal hyphae are dark reddish-brown or purplish-brown in colour, septate at rather long intervals, branched, and 5–7 (–10)μ in diameter. Patouillard described occasional clamp-connections at the base of the basidia, but in none of the specimens seen by us has there been any trace of them, though occasional anastomoses of adjacent hyphae occur (Plate XI, fig. 11).

The hymenium consists mainly, if not entirely, of basidia, which are usually to be found in all stages (Plate XI, fig. 1). The young basidium is a cylindrical erect branch arising from one of the subhymenial hyphae. The basidia are hyaline and full of rather densely granular contents, whereby they stand out markedly from the basal and subhymenial hyphae, which tend to become empty at an early stage. The elongating apex of the basidium gradually becomes bent over in a characteristic crozier-like fashion (Plate XI, fig. 1), and soon afterwards transverse septa appear. The sterigmata arise one from each cell of

the basidium, and as a rule two or three only are found, rarely four (Plate XI, figs. 1, 2). They are subulate in form, and vary in length according to the depth of origin, in order to bring the spores above the surface level of the hymenium; the length may be from 10 to 15 or 35μ, and the width at the base 3·5–4μ. The spores are hyaline, ovate, elliptic oblong, or usually somewhat reniform, with practically no apiculus, 10–12 (–15) × 6–7μ (Plate XI, fig. 3).

The cytology of *Helicobasidium* has not been worked out in detail, but such observations on nuclear behaviour as have been made from stained preparations have indicated that the fungus may be interesting in this respect.

The mycelium of *Helicobasidium*, as far as observed in the fructification, is binucleate, the two small nuclei occurring usually rather close together near the middle of each cell (Plate XI, fig. 7, and Plate XII, figs. 13, 14). In the very young basidium there appears to be a single larger fusion nucleus, which remains until the crozier form has been assumed (Plate XII, fig. 15). The stages of division of the fusion nucleus have not been followed, and it is possible that irregularities occur. The cells of the septate basidium, before the development of sterigmata, are uninucleate (Plate XII, fig. 16), but division of this nucleus apparently may occur at a very early stage. Sometimes distinctly one nucleus only has been seen in the sterigma, while the very young spore shows as yet no nucleus (Plate XII, fig. 17). In other cases two nuclei may be observed in the sterigma, or one in the sterigma and one in the young spore (Plate XII, figs. 18–20). The mature spore appears to be usually binucleate (Pl. XII, fig. 21). It is possible however that the nucleus occasionally does not divide before entering the spore, and that a uninucleate spore and mycelium may result.

Morphological comparison of the mycelia of *Helicobasidium purpureum* and of *Rhizoctonia Crocorum*.

At first, before any fresh material was available, a careful examination was made of herbarium specimens of *Helicobasidium* in order to compare more closely the mycelial characters of the fungus with those of *Rhizoctonia*. The hyphae of the two fungi were found to be so much alike that the authors decided that their hypothesis was well worth testing and to this end the cultures of *Rhizoctonia* were begun. Later observations made from fresh specimens of *Helicobasidium* have confirmed the resemblance as to mycelial characters.

The vegetative hyphae of *Helicobasidium* are purple-brown in colour, very even in diameter for long distances, thick-walled and rather rigid when old, and in the septation, mode of

branching, and absence of clamp-connections cannot be distinguished from the typical hyphae of *Rhizoctonia Crocorum* (cf. Plate XI, figs. 11 and 12). Further, short swollen cells such as occur in connection with the sclerotia of *Rhizoctonia*, as figured by Duggar (*l.c.* p. 418), have also been found occasionally in *Helicobasidium*, where the hyphae become closely aggregated. There is also a resemblance between the two fungi in the development of mycelial strands, which adhere closely to the roots or other structures bearing the fungus.

With the object of checking the resemblance in external form, various strains of *Rhizoctonia* and of the growth obtained in culture from spores of *Helicobasidium* have been stained for nuclei. The first strain of *Rhizoctonia* which was isolated, namely that from red clover, was found to have only one nucleus in each cell (Plate XI, fig. 9). On the other hand, strains from potato and sugar beet possess very distinctly two nuclei in each cell, placed usually towards the middle as in the subhymenial hyphae of *Helicobasidium* (Plate XI, fig. 10). There is no difference in the parasitism of these strains, as successful inoculations have been carried out with all three.

Coming now to *Helicobasidium*, growths from spores, though not from single spores, have been stained with the result that a similar variation in nuclear behaviour has been observed. The strains tested were particularly those used in inoculation experiments. Of five of these, three had only one nucleus per cell (Plate XI, fig. 7), one was regularly binucleate (Plate XI, fig. 8), as is the mycelium of *Helicobasidium* in nature, while in the fifth both uninucleate and binucleate cells were present. The significance of these nuclear differences is not at present understood, and the subject would probably repay more exact cytological investigation.

Spore Germination and Growth in Culture of *Helicobasidium purpureum*.

The spores of *H. purpureum* germinate readily in the presence of moisture, and at ordinary room temperatures will put out short germ-tubes within twenty-four hours (Plate XII, fig. 22). In the course of preliminary observations made in hanging drops, it soon became evident, however, that there are difficulties as to further growth. The cytoplasm and nuclei pass into the germ-tube, which continues to elongate very slowly (Plate XII, figs. 22–25). The cytoplasmic contents, however, do not increase in proportion, with the result that there is formed a long empty hypha from which the small amount of apical cytoplasm is cut off by successive transverse walls (Plate XI, fig. 4 and Plate XII, fig. 23). This apparently starved form of

development is particularly marked in sterile water and on Dox's agar, the two media which were used for hanging drops, and most of the spores started on such media sooner or later die out without producing colonies. At the time the cultural experiments with *Helicobasidium* were started the authors had no experience as to suitable media for the growth of *Rhizoctonia*, hence it was necessary to try as many media as possible, both liquid and solid. On all those tried germination was found to be as described, always with the cytoplasm only at the growing apex of an otherwise empty hypha. There were however differences in the degree of further development according to the nature of the medium, and especially according to the relative thickness of sowings of the spores. It was soon noticed that isolated spores were particularly liable to fail (Plate XI, fig. 4), whereas the spores lying close together in a heavy deposit soon began to develop branches from the original germ-tube, and seemed to have better prospects of survival (Plate XI, figs. 5 and 6). For this reason the first stock cultures in 1923 were started from mass deposits of spores, and no attempt was then made to obtain single-spore growths. In some cases small portions of the hymenium were attached to the lids of Petri dishes in such a way that the liberated spores would fall on to the surface of the solid nutrient agar or gelatine. In other cases the spores were collected in moist chambers on clean sterilised glass slips, then suspended in sterile water, and drops of the suspension were spread on the surface of similar solid media. The spore deposits thus obtained were examined microscopically and appeared to be free from any obvious contaminations.

From plates started in this way very slow and apparently pure growth was obtained on several media, most readily on such media as malt extract agar, malt and meat extract agar or gelatine, prune agar, etc. Slight growth occurred on some other media, soil extract agar, Waksman's modified egg albumen agar, etc., but the first mentioned were found to be most suitable and have been used in all subsequent work with spores.

One of the difficulties in dealing with this organism has been its extremely slow rate of growth. In heavy spore deposits, the first visible indication of growth is seen in about four to six days at favourable temperatures, in the form of a slight purplish discolouration of the medium. In about ten days small colonies just visible to the eye are established. With isolated spores growth is much slower. In ten to fourteen days, at room temperatures, such spores may produce only two or three branches from the original germ-tube, while colonies are barely visible to the eye even after a month. If the cultures are incubated at 25° C. growth is a little more rapid. All cultures are charac-

terised by the development of an intense vinaceous colour in the substratum, accompanied usually by the precipitation of small rhomboidal crystals. The aerial mycelium is at first whitish to pinkish lilac. In a few cases it soon assumes more or less of the reddish brown or purplish colour which is characteristic of *Rhizoctonia*, the purple tinge being particularly noticeable on the more acid media such as prune agar. In the majority of cases however the aerial growth remains for a long time pale, and in such cultures there frequently appear in about a month small raised tubercles, which eventually become pustules of conidia of the type which is characteristic of the genus *Tuberculina* (Plate XII, fig. 26).

Most of the known species of *Tuberculina* are found associated with rust fungi, and have been regarded as parasites of the rusts. Hence, when conidia of this type appeared in the first multiple-spore cultures, it was thought probable that they belonged to an intruder, although no trace of such a fungus had been seen in any of the material used for making the spore-deposits. Unfortunately, by the time this difficulty arose it was too late to obtain further fresh material of *Helicobasidium*, and an effort was therefore made to separate what seemed to be two organisms by means of hyphal characters. In some of the cultures there was a radiating marginal zone of darker purplish hyphae, growing closely adpressed to the agar, which were morphologically very like those of *Rhizoctonia*. In other cultures there appeared after a time erumpent, dark purplish, compact masses of hyphae, almost sclerotium-like in appearance (Plate XIV, fig. 36). Such cultures gave the impression of being mixed growths, and it was thought that the darker hyphae must belong to the true *Helicobasidium*. It was not found possible to cut off single hypha tips, but by plating out teased-out portions of the compact masses, growth was obtained in two cases from what appeared to be single hyphal fragments. These two strains (*B* and *C*), when grown further, developed only the dark hyphae, and in fact acquired an appearance similar to that of various strains of *Rhizoctonia*, with no further development of conidia on any medium. They will be mentioned again in connection with inoculation experiments.

At the same time the conidia were plated out, and a few cultures from single conidia were transferred to tubes of malt and meat-extract agar. The further development of these single-spore cultures was surprising, in that they, also, developed at once the characteristic purplish brown mycelium, and remained continuously dark-coloured and quite sterile.

In the spring of 1925 fresh material of *Helicobasidium* was obtained, this time associated with root-rot in *Urtica dioica*.

Further specimens from the same locality were sent in April of 1926. Having now some experience as to suitable media for development of the fungus, the authors started plates in the hope of obtaining growth from single spores. Even on the most favourable media there seems to be always a tendency for many of the more isolated spores to die out after making very little growth. Development from the less isolated spores is more certain, but when several spores have germinated fairly close together, the isolation of guaranteed single-spore growths becomes difficult on account of the curious method of germination already described, with formation of a long (up to 2 mm. or more), wandering, empty tube which becomes almost invisible. Numerous moderately separated spores were transferred to fresh plates as soon as growth seemed promising, and from these a number of practically certain single-spore cultures were obtained.

Cultures on malt agar from single spores have shown variations equally as puzzling as those which originated from mass spore-deposits. The great majority at first produced pale-coloured aerial mycelium, and rather compact, lumpy growth. One or two strains, however, became more or less brownish almost at once, and developed more spreading and closely adpressed hyphae. Many of the former in the 1925 isolations produced conidia, and of the 1926 isolations all the single-spore strains tested produced conidia abundantly when transferred to potato plugs (Plate XIV, fig. 37). Hence there is no doubt that the conidia really belong to the *Helicobasidium* and do not, as was first thought, indicate an impurity. There seems to be an undoubted tendency for the power to produce conidia to be lost after a long period *in vitro*. Cultures which in 1923 were producing *Tuberculina* pustules abundantly now form very few, if any, conidia. Similarly, some of the subcultures from 1925 isolations have now ceased to produce conidia, and one at least has a luxuriant reddish brown growth of aerial hyphae not unlike that of a strain of *Rhizoctonia* from alfalfa.

Description of conidial form, and comparison with other species of *Tuberculina*.

The first indication of the formation of conidia in cultures is the development of small tubercles towards the centre of the colony. Sometimes these occur irregularly, but more often they are arranged in a ring, giving a rosette-like effect. The middle of each tubercle becomes slightly indented and acquires a violet colour and a smooth surface which contrasts sharply with the pale hyphal margin. As the conidia are formed the colour becomes slightly more reddish, the final tint of the conidia in

mass being from vinaceous-fawn to vinaceous-russet. When the conidia are developed abundantly, as on potato plugs, they fall away from the acervuli, and the base and inner walls of the culture tubes become covered with the dusty, vinaceous powder.

The structure of each acervulus is that of the genus *Tuberculina*. In the early stages the conidiophores line the base of a slight depression, but eventually they grow out to form a convex sorus of the usual Tubercularíaceous type. The conidiophores are erect, unbranched, unseptate except at the base, very closely crowded, obclavate, or, after development of the first conidium, slightly pointed at the apex, about 25–35 × 4·5–5·5μ (Plate XII, fig. 26). The conidia are usually globose, 10–16μ in diameter, but may sometimes be elliptical or ovate, 10–18 × 9–15μ (Plate XII, figs. 26, 27). Each conidium has two nuclei, which on germination pass with the cytoplasm into the germ-tube (Plate XII, figs. 28, 30). As in the case of the basidiospores, the cytoplasm follows the growing apex and a long empty tube is left behind (Plate XII, fig. 30). The regular *Tuberculina* pustules just described are typical of comparatively recent isolations. Along with them there occur also conidia borne apparently on ends of ordinary projecting hyphae, and these latter tend to be deeper in colour and more variable in shape. They suggest in fact chlamydospores. In strains which have been growing for a long period *in vitro* the second type of conidium is more abundant (Plate XII, fig. 29).

Comparison with other species of *Tuberculina* leaves no doubt as to the affinities of this conidial form. In habit and in the constant presence of two nuclei the species resembles most closely *T. persicina* Ditm. as described and figured by Cornu (13), Sappin-Trouffy (14) and others. It differs from that species, however, in its larger and sometimes elliptical or ovate spores. The method of germination of the conidia is similar to that described by Cornu (13) for *T. persicina*, and by Tubeuf (15) and Lechmere (16) for *T. maxima*. The latter species also has large conidia, but its mycelium and spores are constantly uninucleate, as observed by Lechmere (16) and verified by us.

With regard to the conidial form already mentioned, which was described by Patouillard as occurring in specimens of *Helicobasidium* from Nice, Patouillard's figure (Tab. Anal. no. 561) represents an arrangement of erect, unseptate conidiophores arising from the coloured basal hyphae, which bears a slight resemblance to the acervulus found in culture. The conidiophores, however, are figured with a much more drawn-out apex, and the conidia are long-elliptic, not at all globose. Unfortunately the specimens of *H. purpureum* var. *Barlae* which are in the Kew Herbarium show no trace of conidia, hence it

has not been possible to check Patouillard's description. None of the material of *Helicobasidium* we have examined has ever shown any development of conidia in nature.

Comparison of the growth in pure culture of *Helicobasidium* and *Rhizoctonia*.

During the period of three and a half years that the cultural work with *Helicobasidium* has been in progress, opportunity has arisen to grow also several strains of *Rhizoctonia* for comparison. In addition to the strain from red clover, whose growth in culture has already been described (5), we have since isolated the fungus from infection cushions formed on potato, sugar beet, mangold, and stinging nettle (*Urtica dioica*)—in the latter case associated with *Helicobasidium*. We have also received from Dr Kotila of Michigan a strain isolated by him from alfalfa, and from the Central Bureau for Cultures at Baarn a strain isolated by Wollenweber from *Beta vulgaris* (variety not stated).

These seven strains, while agreeing in general macroscopic and microscopic characters, such as colour, size and septation of hyphae, etc., yet show considerable variation amongst themselves in cultural characters when grown on the same medium and under the same conditions. Thus on malt extract agar, the medium which has been used constantly in the more recent work, the alfalfa strain, as one extreme type, has always given more luxuriant and more rapid growth than any of the others, and forms a characteristic radiating mycelium which spreads round the sides of the tube. This strain is at first very pale, and always shows a pale marginal growing zone. The potato strain also gives fairly luxuriant aerial growth, but less pale at first, more uniform in colour, and without the striking radiating growth. The strain from red clover is also uniform in colour, and produces less aerial mycelium, most of the growth being closely adpressed to the medium. The strain from *Beta vulgaris* has a general appearance somewhat like the clover strain, but has a tendency to form large, sclerotium-like lumps in old cultures, while that from sugar beet gives also lumpy growth with greater tendency to violet coloration than most forms. The mangold strain comes at the other extreme of the series, the growth being very compact and irregularly lumpy, with little or no spreading mycelium. The fungus isolated from roots of *Urtica* has been, until recently, always paler and slower in growth than any of the others, and has formed scattered lumpy colonies much like the early isolations of *Helicobasidium* from spores. A comparatively recent sub-culture, however, has developed the more normal brownish

spreading mycelium, and all subsequent transfers from this tube have retained this character.

The various strains also vary somewhat when grown on different media, and sometimes at different periods, for no apparent reason. Thus the clover strain on potato plugs sometimes remains dark, but occasionally gives at first a quite pale growth.

The variation in macroscopic appearance in cultures of *Rhizoctonia* is paralleled closely by similar variation observed in the cultures made from spore deposits of *Helicobasidium*. As already noted, the *Rhizoctonia* from *Urtica* resembles most closely the pale-coloured cultures which form the majority in first isolations from spores. The fact that a brown strain has appeared in subcultures from this is exactly similar to the early experience with subcultures from *Helicobasidium*, when growths of such different appearance were obtained that we were for a long time convinced that the original cultures must have been mixed. A further interesting parallel is found in the presence of conidia. When it was noticed that potato plugs favoured the development of conidia, the strains of *Rhizoctonia* were also transferred to that substratum. While most of them gave nothing but the usual sterile growth, the *Urtica* strain developed *Tuberculina* conidia, with typical pustules such as occur in many *Helicobasidium* strains. Further, the mangold strain (which has been proved to cause *Rhizoctonia* root-rot) gave similar conidia, though in this case they were not developed in regular pustules, but resembled rather the conidia of *Helicobasidium* strains that have been grown in artificial culture for a long period (Plate XII, fig. 31).

Another point of resemblance appeared when strain *B* of *Helicobasidium* was grown in Petri dishes and allowed to get rather dry. Here sclerotium-like bodies developed exactly resembling those of the clover *Rhizoctonia* when grown under similar conditions ((5), p. 299).

The temperature relations of the two fungi appear to be alike. The details have not been worked out for *Helicobasidium* as for *Rhizoctonia* (5), but its optimum temperature for growth appears to lie similarly in the neighbourhood of 25° C.

Inoculation Experiments.

Except for the conidia above described as occurring in two cases, no strain of *Rhizoctonia* has yet produced any form of fructification in culture, and there seems to be little hope of obtaining the perfect stage under artificial conditions. Hence the only method of proving a connection between these two

fungi would seem to be that of producing the typical root-rot by inoculation with pure cultures of *Helicobasidium*.

To this end a large number of inoculations of living plants, chiefly various clovers, and occasionally carrot, have been carried out with strains derived from spore cultures of *Helicobasidium*, and at the same time parallel inoculations have been made with the strains of *Rhizoctonia* available. In all cases the plants have been grown in large pots (8″ to 10″). In the first experiments the soil used was the ordinary partially sterilised, potting soil as used at Kew; in later work the pots and soil were sterilised in the autoclave. In working with a fungus such as this, which grows only very slowly in the soil and does not readily produce spores, the danger of accidental contamination is very slight, but as a precaution control pots in adequate numbers have always been used to check results.

The fungus *Rhizoctonia Crocorum* does not appear to be a very virulent parasite under ordinary English conditions. The few inoculations made in open ground have failed, and when diseased clovers have been transplanted to fresh uninfected ground they have recovered and there has been no further spread of the fungus on their roots. Inoculations made in pots have frequently succeeded, but there have also been failures, and the right conditions for infection are not altogether understood. There is some indication that infection takes place more readily in a sandy, well-aerated soil, provided sufficient moisture is present, than in heavy soils. There is also some indication from the results obtained by the authors that after growth for a long period *in vitro* on a medium such as meat-malt-extract agar, on which the fungus makes its most abundant development, the *Rhizoctonia* may lose its virulence. Successful inoculations have, however, been obtained with cultures of both *Helicobasidium* and *Rhizoctonia*.

Of the strains of *Rhizoctonia* isolated from infection cushions on diseased roots, that from red clover has produced root-rot with infection cushions on carrot and on various clovers. The strain from sugar beet has also infected carrot and clovers, including lucerne or alfalfa; while those from potato and mangold have produced root-rot in various clovers. Infection with the clover strain was at first very vigorous, but became less so after the cultures had been maintained for two years. The mangold strain has not given a very high proportion of infections. No result has as yet been obtained from inoculations with the strains isolated by Kotila and Wollenweber, nor with the strain we isolated from roots of *Urtica*.

Successful inoculations with cultures derived from spores of *Helicobasidium* have been less frequent. Three strains, all of

which originated from the first specimens, associated with red clover, have produced the typical symptoms of Violet Root-Rot in clovers and carrot. One result was also obtained early in the work with a fourth strain (*C*), but as the plants used in that experiment had been transplanted from a field, thought to be free from infection but not certainly so, there is some doubt as to whether the infection was due to the inoculation. No other inoculations with *C* have given positive results. In 1925 a very large number of pots were inoculated with strains of both multiple and single-spore origin, derived from the *Helicobasidium* associated with *Urtica*, but none of these strains has so far given any infection. It is just possible that the *Urtica* strain may not be infective to the host plants used in these experiments, but the matter will be discussed further in the next section.

The history of the strains of *Helicobasidium* which have given positive results is as follows:

A. Originated from a spore deposit made in April 1923, which was transferred directly to a tube of malt agar on April 19th. This culture produced the compact purple growth described above, portions of which were teased out and plated. Promising-looking hyphae from these growths were transferred to malt agar on June 18th, 1923. A tube used for inoculation on March 24th, 1924, gave no result, but a malt-meat extract subculture from it made on the same day gave positive results when used on April 15th, 1924.

B. The hymenium used for making the original spore deposit on Dox's agar on April 10th, 1923, was growing on oat stubble which was intermixed with affected red clover.

Transfers were made as follows: April 16th, potato agar; May 12th, prune agar. This tube developed the purple compact growths described, fragments of which were plated out on June 3rd (malt agar). A growth which appeared to be coming from a single hyphal fragment was transferred to a tube of malt-meat-extract agar on June 28th, 1923. Subcultures from this tube were those afterwards used for inoculations.

C. The early history of this strain is the same as that of *B*. From the plate made on June 3rd a growth which had certainly originated from a small fragment of a single hypha was transferred to a tube of Jardox gelatine on July 2nd, 1923. Subcultures from this were those subsequently used for inoculations and called *C*.

F. A spore deposit was made on April 14th, 1923, and transferred to spinach agar. Subcultures from this to malt agar were made on May 4th and on June 14th. The cultures had remained reddish brown from the beginning and had produced

no conidia, hence no plating out had been considered necessary. The tube of June 14th and subsequent subcultures were used in inoculation experiments.

The table on p. 135 sets out the method of treatment and results in the successful experiments made with these strains.

Discussion of Results.

The important fact which emerges from the work just recorded is that there is a very intimate association between the Basidiomycete *Helicobasidium purpureum* and the root parasite known as *Rhizoctonia Crocorum*, whatever the nature of the relationship may be. Root-rot, characterised by the presence of the "corps miliaires" or infection cushions which are typical of *Rhizoctonia Crocorum*, has been found in every locality investigated where *Helicobasidium* has been found. Further, the association is so close that in two strains of *Rhizoctonia* isolated in the usual way from infection cushions, conidia similar to those obtained from *Helicobasidium* have been produced in cultures.

The supposition that *Helicobasidium* represents the perfect stage of *R. Crocorum* is supported by these facts of intimate association, by the morphological characters of the hyphae of the two fungi, by their similar rates of growth and temperature relations, and by the results of inoculation of living roots by certain strains derived from spore-cultures of *Helicobasidium*.

The last point is the most important evidence in favour of direct genetic connection between *Helicobasidium* and *Rhizoctonia*. The experiments were carried out with careful controls, and except in the first series of pots the soil used was thoroughly sterilised in the autoclave. These precautions, and the fact that it has been always the same strains, *A*, *B*, and *F*, which have given infections, though with some evidence of declining virulence in the course of time, seem to preclude the possibility of accidental infection. It is true that the results are open to the objection that the strains used were derived from original mass spore deposits, and not from single spores; but care was taken to observe that the spores shed were free from any obvious contaminations, and repeated examination of the specimens of *Helicobasidium* used has revealed no other spore-form than the basidiospores of this fungus.

At the same time, the rather widely different appearance of many of the primary spore isolations of *Helicobasidium* from most of the vegetative isolations of *Rhizoctonia*, and the variable behaviour of cultures, does seem to indicate a possibility that *Helicobasidium* may be another species living in close association with *Rhizoctonia*, so close that separation by

Table showing details of successful inoculations with strains of Helicobasidium.

	Plant	Treatment	Date of Inoculation	Strain	Result	Remarks
1	Red clover	Soil from Kew stock partially sterilised, seed sown 5. VII. 23, transplanted when plants had several leaves.	3. IX. 23, 2. XI. 23	*B*	+ (11. IV. 24)	4 good infections with infection cushions, 2 doubtful, out of total 10
2	Carrot	Soil from Kew stock partially sterilised, seed sown 5. VII. 23, transplanted when plants had several leaves	21. IX. 23, 2. XI. 23	*B*	+ (16. III. 24)	4 plants with infection cushions out of 10
3	Carrot	Same soil as in 1, not sterilised	Not reinoculated	*B*	+ (10. IX. 24)	1 plant badly rotted, 16 clean
4	Mixed clovers	Pots autoclaved, soil inoculated when seed sown	15. IV. 24	*F*	+ (17. IX. 24)	Infection on 3 plants out of 6
5	Alsike	Pots autoclaved, seedlings transplanted from old control pot of 1924	28. VI. 25	*F*	+ (13. X. 25)	5 plants out of 9 infected; soil rather sandy
6	Carrot	Pot autoclaved, seed sown 17. IV. 25 in old control pot of 1924, transplanted 14. V. 25	28. VI. 25	*B*	+ (13. X. 25)	1 plant infected out of 5
7	Mixed clovers	Plants transplanted from field	14. IV. 24	*C*	+ (18. XI. 25)	Few plants infected 1925; doubtful case, long period, and original soil not sterilised
8	Alsike	Soil autoclaved, seeds sown in autoclaved soil and seedlings transplanted to 2 small pots	28. VI. 25	*A*	?+ (Oct. 1925)	No infection cushions formed, but one plant showed slight weft of hyphae on root
9	Mixed clovers	Soil autoclaved, inoculated when seed sown	15. IV. 24	*A*	+ (5. I. 25)	50 % of numerous plants in pot infected; tap-root destroyed in some instances

ordinary cultural methods is difficult or impossible. It has been already described how the appearance of *Tuberculina* conidia in their first isolations led the authors to suppose that these were mixed growths. There is no doubt that this conviction caused progress to be slower than it might otherwise have been. With the successful development of single-spore growths, the conidial form has been shown to belong to *Helicobasidium*. There still remains the difficulty, however, that five out of the seven strains of *Rhizoctonia* studied have never produced conidia, and that successful inoculations with *Helicobasidium* have been much less frequent than those with *Rhizoctonia*.

If infection could be obtained with a single-spore culture the case would be proven. Unfortunately the only single-spore cultures we have at present are those derived from the fungus associated with *Urtica*, and as already noted neither the *Rhizoctonia* nor any of the spore strains isolated from this host has as yet given any infection. It is possible that this particular strain is not pathogenic to the plants used in our experiments. On the other hand, such cross-inoculations as have been carried out with strains of *Rhizoctonia* from different host-plants have tended to disprove the existence of any great biologic specialisation in this fungus.

It is obvious that one of the most pressing needs is for more exact information as to the conditions under which *Rhizoctonia* will infect living roots. There have been many failures even in experiments with known infective strains; hence negative results have not the same importance they would have in the case of a more virulent parasite.

Another, as yet unexplained, complication is the extraordinary variation in the appearance of cultures from time to time. There are two main types of growth; one is pale-coloured, compact and lumpy, and this usually produces conidia on suitable media; the other consists of spreading purplish brown hyphae which remain dark-coloured and never produce conidia, but may sometimes form sclerotium-like bodies. When subcultures are made from the dark mycelium they retain these characters and never again produce the pale form of growth, a phenomenon which is illustrated by the history of strains *A*, *B*, and *C* of *Helicobasidium* and by the recent appearance of a dark-coloured, apparently permanently sterile strain in a subculture from the conidia-producing *Rhizoctonia* from *Urtica*.

It is tempting to suppose that *Helicobasidium* is an extremely plastic organism, from which mutants may readily arise. Some support for such a view is provided by the fact that in Petri-dish cultures, both of *Helicobasidium* and of *Rhizoctonia*, a curious sectoring effect is sometimes observed. Sectors of an otherwise

pale-coloured colony may develop the deeper brownish colour; or the hyphae of one sector may suddenly begin to grow much more rapidly than the rest of the colony, so that a markedly lobed outline is produced in place of the previous regular circular shape.

If the explanation of the growth differences observed is to be found in such a tendency to variation (or perhaps mutation), it is conceivable that the pathogenicity of the fungus is subject to similar variation. If that is so, the non-success of so many inoculations made with spore cultures may be due to the fact that the majority of strains are but feebly if at all parasitic, whereas occasionally a more virulent form appears which will produce *Rhizoctonia* root-rot on a suitable host plant. The fact mentioned above, that the mangold strain of *Rhizoctonia* (which produces conidia) is rather less virulently parasitic than a quite sterile form like that from clover, agrees with the results of experiments with *Helicobasidium*, where conidia-bearing strains have produced no infection, and all successful inoculations have been achieved with the derived sterile strains.

From the taxonomic point of view a further interesting question is opened up by the discovery that *Helicobasidium* possesses a conidial stage which morphologically and cytologically is indistinguishable from certain species of the genus *Tuberculina*. The known species of *Tuberculina* are usually found in association with rust fungi, on which they have been supposed to be parasitic, and they have not hitherto been genetically connected with any higher form. In this connection there has arisen an interesting coincidence, which may, or may not, be of significance. In searching through the literature the authors discovered the description of *Rhizoctonia Menthae* B. and Br. (17), in which mention is made of globose conidia. Berkeley and Broome referred the fungus to the genus *Rhizoctonia* on account of the presence of sclerotia, and a weft of violet hyphae resembling those of *R. violacea* (*R. Crocorum*). On examination of the type specimen of *R. Menthae* in the British Museum, it was found that the conidia described are those of a *Tuberculina*, which has practically replaced the aecidia of *Puccinia Menthae*, only a few aecidiospores remaining to prove the existence of the usual association.

Summary.

1. Fertile *Helicobasidium purpureum* has been found in very close association with root-rot characterised by infection cushions of *Rhizoctonia Crocorum* in distinct localities, on (*a*) red clover, (*b*) *Mercurialis perennis*, (*c*) *Urtica dioica*.

2. In order to test the possible connection of the two fungi, they have been studied morphologically, culturally, and as to pathogenicity.

3. Morphologically the hyphae of *Helicobasidium* are exactly similar to those of *Rhizoctonia*, having the same type of branching, septation, and absence of clamp connections. They also resemble one another in nuclear characters, both fungi having sometimes one but more often two nuclei per cell.

4. Seven strains of *Rhizoctonia Crocorum* have been compared with numerous spore isolations of *Helicobasidium* as to cultural characters. Both fungi show considerable variation in colour and type of growth. Conidia belonging to the genus *Tuberculina* are frequently produced in cultures of *Helicobasidium*, and similar conidia have been found in strains of *Rhizoctonia* isolated from *Urtica* and from mangold. In cultures of *Helicobasidium* which originated from multiple spores there sometimes develop in subcultures strains which acquire the dark colour characteristic of the sterile *Rhizoctonia* strains, and which remain henceforth sterile. A similar variation has arisen in the *Rhizoctonia* isolated from *Urtica*, which at first produced only pale growth, with a tendency to form conidia.

5. Successful inoculations, with the production of typical root-rot, have been obtained with four strains of *Rhizoctonia*, and with three of the dark-coloured strains derived from *Helicobasidium* spore cultures. The host plants used were various legumes and carrot. In every case precautions were taken to exclude the possibility of accidental infection, and adequate controls were used.

6. The strains of *Helicobasidium* which have proved infective all originated from specimens associated with red clover. None of the strains from *Urtica*, nor the *Rhizoctonia* isolated from *Urtica*, has up to the present produced any infection on clovers or on carrot. Other strains of *Rhizoctonia*, however, have not given evidence of any specialisation in parasitism.

7. The bearing of the observations made is discussed. While there have been inconsistencies in behaviour, it is possible that these are due to the fact that the organism is very variable, and that not all the strains are equally parasitic. It has also to be borne in mind that practically nothing is known as to the conditions for infection with *Rhizoctonia Crocorum*.

The balance of the evidence is considered to favour the view that *Helicobasidium purpureum* (Tul.) Pat. is the perfect stage of *Rhizoctonia Crocorum* (Pers.) DC.

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DESCRIPTION OF PLATES

Plate XI.

Fig. 1. *Helicobasidium purpureum*. Vertical section of sporophore showing hymenium and part of subhymenial tissue. × 450.

Fig. 2. *H. purpureum*. Two basidia. × 500.

Fig. 3. *H. purpureum*. Spores. × 500.

Fig. 4. *H. purpureum*. Germination of an isolated spore, showing poor growth and gradual dying of hyphae, with possible origin of two colonies. The dotted portions contain protoplasm, the remaining hyphae being empty.

Figs. 5 and 6. *H. purpureum*. Late germination of spores in a mass deposit on meat-malt-extract agar, showing favourable influence of the presence of other colonies. × about 450.

Fig. 7. *H. purpureum*. Hyphae from strain *F* in pure culture, showing two nuclei in each cell. × 500.

Fig. 8. *H. purpureum*. Hypha from strain *C* in pure culture, showing one nucleus per cell. × 500.

Fig. 9. *Rhizoctonia Crocorum.* Hypha from red clover strain in pure culture, showing one nucleus per cell. × 500.

Fig. 10. *R. Crocorum.* Hypha from sugar beet strain in pure culture, showing two nuclei in each cell. × 500.

Fig. 11. *H. purpureum.* Hyphae on stem of *Urtica dioica.* Drawn from specimen in Jaap, Fung. Sel. Exs. No. 389. × 500.

Fig. 12. *R. Crocorum.* Surface hyphae from potato. × 500.

PLATE XII.

Figs. 13–20. Successive stages in the development of basidium and spores. × 800. Fig. 13. Terminal cell of hypha with two nuclei. Fig. 14. Beginning of fusion. Fig. 15. Young basidium with large fusion nucleus. Fig. 16. Basidium after completion of divisions of fusion nucleus. Fig. 17. Development of sterigmata and spores. Fig. 18. Division of nucleus after entering sterigma. Fig. 19. Passage of first nucleus into spore. Fig. 20. Second nucleus entering spore.

Fig. 21. *H. purpureum.* Binucleate basidiospores. × 800.

Fig. 22. *H. purpureum.* Germination of basidiospores. × 800.

Fig. 23. *H. purpureum.* Germinating basidiospore, showing passage of cytoplasm to extreme tip of germ tube. × 800.

Figs. 24, 25. *H. purpureum.* Development of first branches of germ tube from basidiospore, showing binucleate condition. In Fig. 25 the nuclei have divided but a wall has not yet been formed. × 800.

Fig. 26. *H. purpureum. Tuberculina* conidial form as developed in pure culture, strain from red clover: (*a*) portion of conidial layer of pustule, (*b*) isolated conidiophores. × 500.

Fig. 27. *H. purpureum.* Conidia from pure culture, *Urtica* strain. × 500.

Fig. 28. *H. purpureum.* Conidia, showing two nuclei. × 800.

Fig. 29. *H. purpureum.* Conidia formed in old cultures, not in definite pustules (? chlamydospores). *Urtica* strain. × 500.

Fig. 30. *H. purpureum.* Germination of *Tuberculina* conidia. × about 350.

Fig. 31. *R. Crocorum.* Conidia developed in culture of mangold strain on potato plug. × 500.

PLATE XIII.

Fig. 32. *Red clover.* Showing fructification of *Helicobasidium purpureum* on petioles and stems at ground level, and infection cushions of *Rhizoctonia Crocorum* on the tap-root. Natural size.

PLATE XIV.

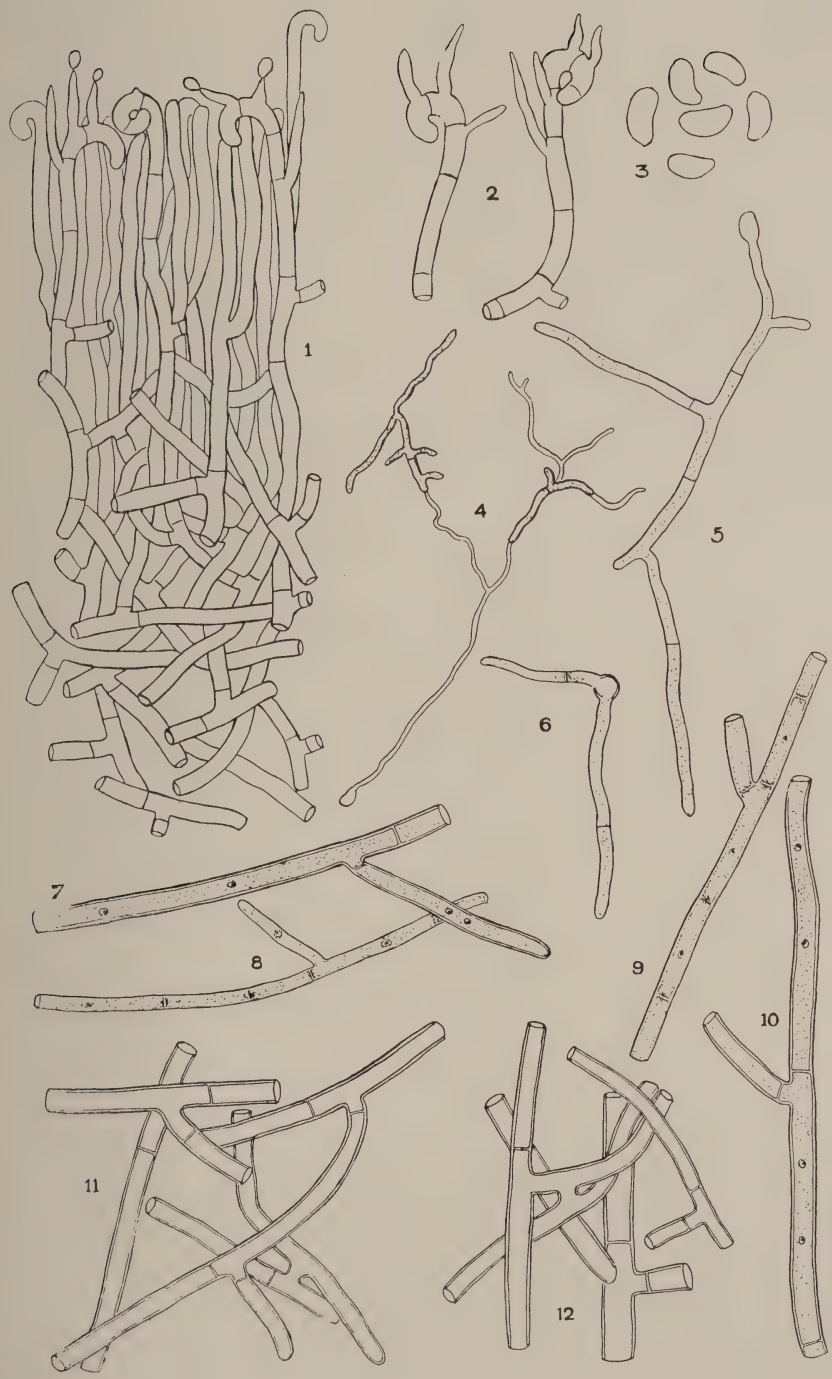
Fig. 33. *Mercurialis perennis.* Fallen ash twig on left covered with superficial felted mycelium; small root in centre showing numerous infection cushions of *R. Crocorum.*

Fig. 34. Portion of an underground runner of *Mercurialis perennis* showing rotted cortex with infection cushions of *R. Crocorum.*

Fig. 35. *Urtica dioica.* Showing fructification of *Helicobasidium purpureum* on stem above ground, and infection cushions of *R. Crocorum* on roots and underground runners.

Fig. 36. *Helicobasidium purpureum* (red clover strain). First isolations from spores, showing two kinds of growth.

Fig. 37. *Helicobasidium purpureum* (*Urtica* strain). Single-spore culture on potato plug, showing numerous pustules of conidia of the *Tuberculina* type.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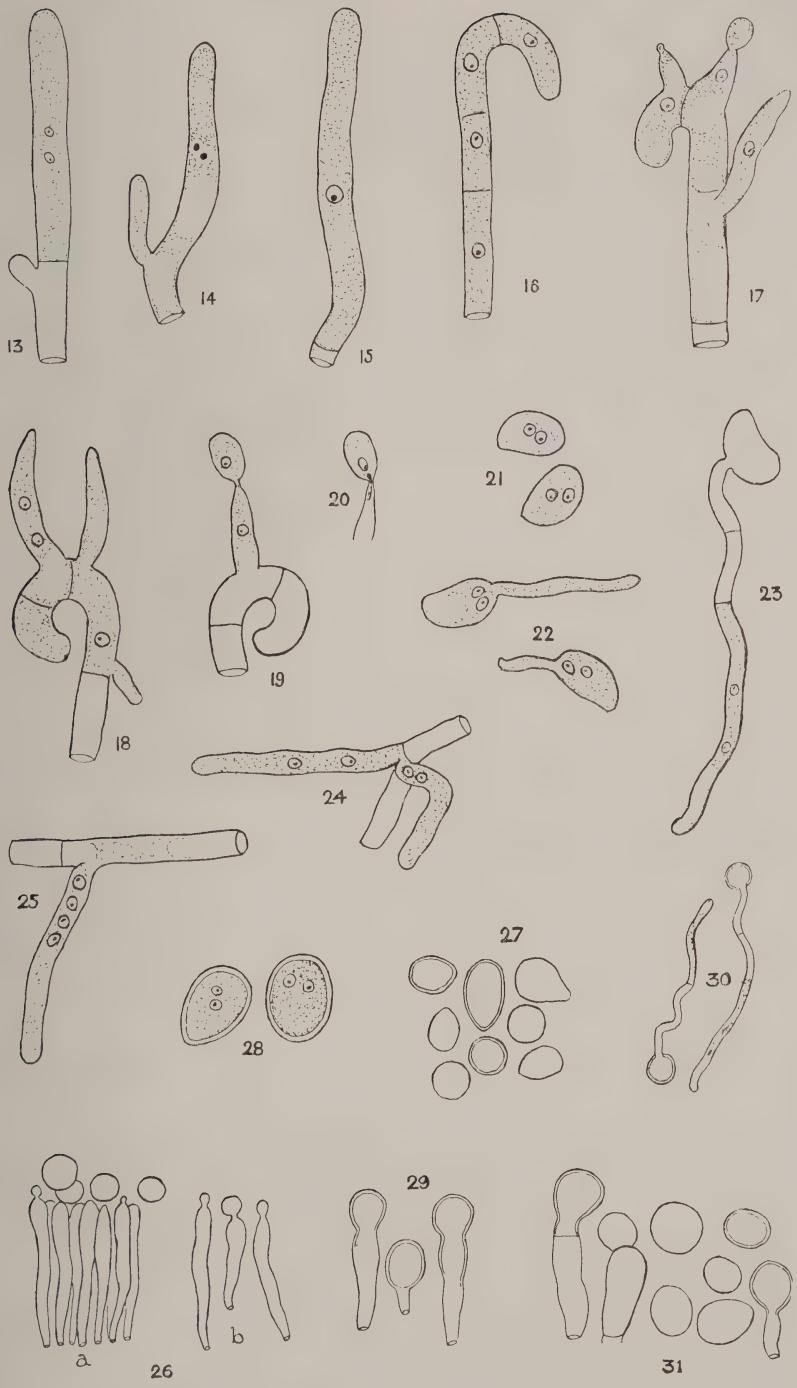
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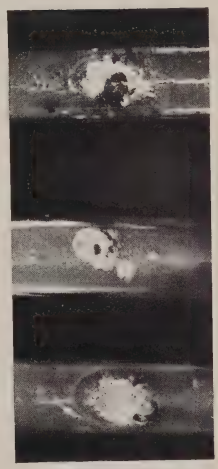

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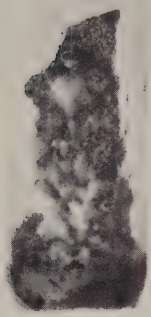

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MACROPHOMINA PHASEOLI (MAUBL.) COMB. NOV. THE PYCNIDIAL STAGE OF RHIZOCTONIA BATATICOLA (TAUB.) BUTL.

(With 1 Text-fig.)

By S. F. Ashby, Mycologist, Imperial Bureau of Mycology.

In 1912 Shaw (1) described an apparently sterile fungus with minute black sclerotia as the cause of a seedling disease of jute, cowpeas, groundnuts and cotton at Pusa, India. He referred it erroneously to *Rhizoctonia Solani* Kühn which is now regarded as the sterile stage of *Corticium Solani* (Prill. and Del.) Bourd. and Galz. Taubenhaus (4) in 1913 described a similar sclerotial form as the cause of a charcoal rot of the sweet potato in New Jersey, U.S.A. and named it *Sclerotium bataticola*. In 1915 Shaw and Ajrekar (2) listed twenty-one hosts of his *Rhizoctonia* in India, of which twenty were herbaceous. In 1924 Small (5) described a *Rhizoctonia* which developed black sclerotia of variable size and shape in the diseased roots of many woody plants in Uganda; he named it *Rhizoctonia lamellifera*. In 1925 Briton-Jones (8) gave the name *Rhizoctonia bataticola* (Taub.) Butl. to a sclerotium causing a root-rot of cotton, french beans and cowpeas in Egypt; this binomial was based on a comparison by Butler of pure cultures of the forms from India, Egypt and America which showed them to be identical. In 1926 Small (7) recognised the identity of his fungus with the forms from India, Egypt and America and abandoned the name *R. lamellifera*.

In 1916 Sawada (9) described a disease of jute (*Corchorus capsularis*) in Formosa caused by a pycnidial fungus which he named *Macrophoma Corchori*. In pure culture minute black sclerotia were developed which he thought might be immature pycnidia. In 1924 Shaw (3) published further studies on the *Rhizoctonia* disease of jute (*C. capsularis* and *C. olitorius*) in India, which he had first described in 1912, and found a *Macrophoma* constantly associated with the minute black sclerotia in the cortex. Pure cultures from single spores of the *Macrophoma* developed the sclerotial form. An exchange of cultures with Sawada resulted in agreement that the forms in India and Formosa were identical, and Shaw adopted the name *Macrophoma Corchori* Saw. for his fungus. Repeated isolations from single spores when inoculated on jute caused the sclerotial disease and the appearance of *Macrophoma* pycnidia in the lesions. Isolations from potato (*Solanum tuberosum*) and cotton when inoculated on jute also produced the sclerotial disease and

pycnidia. Cultures grown from single spores when inoculated on hosts other than jute gave rise to sclerotial disease but no pycnidia developed. Shaw concluded that the pycnidial form is restricted to jute. Exchange of cultures with Taubenhaus established the identity of the Indian and American forms, but when the American strain from sweet potato was inoculated on jute, although sclerotial disease resulted, no pycnidia formed.

Macrophoma Phaseoli; marginal growth showing sclerotia of three colonies developing from single spores out of pycnidia on bean stems from S. Carolina, U.S.A.; plate culture on Dox's agar, 5 days old at 24° C. × 5.

In 1925 Dr Small sent from Uganda to the Imperial Bureau of Mycology, roots and the lower parts of the stem of a plant of *Sesamum indicum* attacked by the sclerotial disease, and, later in the year, a dry fruit of sesame bearing pycnidia of a *Macrophoma* but no sclerotia, was received from Mr Snowden, Acting Mycologist in Uganda. Six months later the specimens were examined again and *Macrophoma* pycnidia identical with

those on the fruit and closely resembling *M. Corchori* were found scattered on the stem lesions caused by the sclerotial fungus. An attempt was then made to germinate spores from teased up pycnidia on the fruit; many were found to be viable and ten vegetations from single spores were secured and transferred to a modified Dox's agar medium*. After a few days at 26° C. the growths developed minute black sclerotia and each was found to be a pure culture of *Rhizoctonia bataticola*. It was evident that a *Macrophoma* formed part of the life cycle of the sclerotial fungus on sesame, and confirmation was obtained of Shaw's observations on the *Macrophoma* stage in India. There are at least two records of similar pycnidial forms on sesame in the East, one by Petrak (11) in 1923, who described *Macrophomina philippinensis* on sesame stems from the Philippines and the other by Sawada (10) in 1922 who named a *Macrophoma Sesami* on stems in Formosa. Through the courtesy of Dr Petrak, his type has been examined and found to agree in essentials with the form on sesame in Uganda; this he has also examined and confirmed its identity with his type. Sawada's description is in Japanese†, but his two figures of a section of the pycnidial wall showing conidiophores and of the spores suggest close similarity. Sawada's description of *M. Corchori* and Shaw's data cover the form from Uganda. A *Macrophoma* on leaves of *Corchorus* sp. from Dacca, Bengal (Herb. Crypt. Ind. Orient. No. 2293) has been examined and found to fit the descriptions of the form on the stems of jute in India and Formosa. The type of *Macrophoma Cajani* Syd. and Butl. (1916) (12) on living stems of pigeon-pea from Pusa (India) has been examined and is in close agreement with the *Macrophoma* on jute and sesame. Through the courtesy of Dr C. A. Ludwig specimens of bean stems (*Phaseolus vulgaris* L.) from South Carolina and Mississippi, bearing pycnidia of the *Macrophoma* type associated with minute black sclerotia, have been examined and proved to be alike. Eight vegetations developed from single spores were found to be pure cultures of *Rhizoctonia bataticola*, a proof that the sporing stage of that fungus occurs in the United States on beans. The disease on beans (13, 14) was only recently recognised in the United States, where it is known as *Macrophoma* stem-rot or ashy stem blight, the associated pycnidial fungus being referred to *Macrophoma Phaseoli* Maubl. which was described in 1905 (15) on stems of *Phaseolus vulgaris* from Tunis. The pycnidia and spores of the American fungus appear identical with those on jute and sesame and conform to

* Potassium nitrate 2·0: magnesium sulphate (cryst.) 0·5, potassium phosphate (K_2HPO_4) 1·0, cane-sugar 15·0, ferric chloride 1 drop, agar 15·0, water (dist.) 1000.

† See footnote p. 145.

the original description of *M. Phaseoli*. The sclerotial disease of *Phaseolus* spp. has been observed also in India, Egypt, Uganda and Ceylon, but has not been recorded in association with a pycnidial form which has doubtless been overlooked.

Petrak's and Sydow and Butler's types do not show definite indications of sclerotia in the tissues although the intra-matrical mycelium is similar to that of *R. bataticola*. Sclerotia were not found in the wall of the fruit of sesame from Uganda but developed abundantly in cultures from spores in the pycnidia, and sclerotia were not formed in the leaves of jute. It would seem that the *Macrophoma* stage may appear independently on aerial parts of some hosts, and its connection with the sclerotial disease on the same host or on other hosts can be easily overlooked. Definite proof of such connection can be had rapidly by growing cultures from single spores on a medium which favours early and abundant sclerotium development; a modified Dox's agar has been found very suitable for this purpose. Pycnidia and spore formation have not hitherto been detected in pure cultures on any medium. The membranous or subcarbonaceous pycnidia, at first immersed but becoming more or less erumpent at maturity, are globose or depressed globose with an inconspicuous truncate ostiolum and mostly 100–200μ in diameter; a stroma is absent and suggestions of a pseudostroma scanty: the wall consists of 3–4 layers of blackish brown thin-walled angular cells about 9μ in diameter and is lined by a hyaline layer 2–3 cells thick, bearing simple rod-shaped conidiophores 10–15μ in length over its entire surface. The hyaline, continuous, thin-walled conidia with granular contents are variable in shape, elliptical or oval, at times with irregular contour and more or less bent but with no true curvature. The variations in spore size on the same host may be considerable, Shaw giving as a maximum range on jute in India, 16–29 by 6–11μ and Sawada for the same host in Formosa, 16–32 by 7–10μ; the dimensions fall mostly between 16–29 by 6–9μ. The thin-walled conidia, as Shaw has pointed out, have a mean $l : b$ ratio near 3 : 1 and are therefore readily distinguished from the immature hyaline thick-walled pycnospores of *Botryodiplodia Theobromae* Pat. and related forms which show a mean $l : b$ ratio of 2 : 1 or lower.

Petrak has described the *Macrophoma* on sesame stems from the Philippines as the type species of his new genus *Macrophomina* to include pycnidial forms devoid of stroma with long narrow thin-walled elliptical spores which remain hyaline and continuous. With this procedure the author is in agreement as the genus *Macrophoma* is a most heterogeneous group. Petrak and Sydow (16) have in fact been able to refer most of the species

to other genera, *Dothiorella* and *Botryodiplodia* in particular, reducing it to a monotypic genus; the species retained, *Macrophoma pinea* (Desm.) Pet. and Syd. is a more or less stromatic form with large spores 30–50 × 11–20μ and is evidently unrelated to the form considered in this paper. Similar objections apply to its inclusion in *Dothiorella*. As *Macrophoma Phaseoli* Maubl. (1905) is the earliest applicable binomial which the

Measurements in microns of conidia of Macrophomas on jute, sesame, pigeon-pea and beans.

	Observer	μ
Macrophoma Corchori	Shaw	16–27 × 6–8, 17–29 × 6–8, 16–24 × 7–8, 20–27 × 7–9, 16–27 × 7–11, 16–24 × 8–11*
,, ,,	Sawada	16–32 × 7–10
Macrophomina philippinensis	Petrak	16–24 × 6–7·5
,, ,,	Ashby	16–25 × 6–8 (mean of 20 = 20·5 × 7·3)
Macrophoma on sesame fruit Uganda	,,	20–27 × 7–9
Macrophoma on sesame stems Uganda	,,	18–29 × 7–9 (mean of 22 = 25 × 8)
Macrophoma on leaf of jute India	,,	16–28 × 6–8
Macrophoma Cajani	H. and P. Sydow	20–32 × 5–8
,, ,,	Ashby	18–31 × 6–8 (mean of 20 = 26 × 7)
Macrophoma on bean stems S. Carolina and Mississippi	,,	17–30 × 6–9 (mean of 74 = 23·6 × 7·5)
Macrophoma Phaseoli	Maublanc	20–30 × 8–10

* Six sets of measurements on inoculated jute.

author has been able to recognise, the combination *Macrophomina Phaseoli* (Maubl.) nov. comb. is proposed with the undermentioned as synonyms:

Macrophoma Phaseoli Maubl. (1905).
Sclerotium bataticola Taub. (1913).
Macrophoma Corchori Saw. (1916).
Macrophoma Cajani Syd. and Butl. (1916).
Macrophomina philippinensis Petr. (1923).
Rhizoctonia lamellifera Small (1924).
Rhizoctonia bataticola (Taub.) Butl. (1925).
Dothiorella Cajani Syd. and Butl. (1925) (17).
†*Macrophoma Sesami* Saw. (1922).

The sclerotia, which show some differentiation between cortex and medulla, are smooth, black and hard, and variable in size

† A translation of Sawada's description has been obtained; pycnidia 110–160 μ, spores 18–27 × 7–10 μ; on stems and fruits.

and form. In the tissue of herbaceous plants they range from 50–150μ in diameter but in the roots of woody plants Small found them up to ·8 × 1·0 mm. in size in cultures the variation is from 50–200μ.

This sclerotial fungus is of wide geographical distribution, ranging from Formosa, the Philippines, India, Ceylon, East Africa, Palestine and Egypt to the West Indies* and the eastern United States. It causes a seedling blight, stem-rot and root decay of a large range of important economic herbaceous crop plants, a tuber-rot of sweet potatoes and fruit-rot of peppers (18). In Uganda (5), it has been found associated with a root decay of some fifteen introduced woody plants including coffee, cacao and tea, and recently Small (19, 20) has found it in Ceylon in association with root diseases of many woody plants including tea, *Hevea*, cacao and citrus. Its parasitism appears to be much influenced by the effects of environmental and nutritional conditions on the host: its restriction in Uganda to introduced plants is suggestive. In Formosa (22) applications of wood ashes and lime have appreciably reduced losses in jute, and in India (21) on an acid laterite soil, manuring with potash or ash of water hyacinth (*Eichornia crassipes*) has markedly lessened attack on the same host which is sensitive to soil deficiency in available potash.

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* It was isolated in 1926 from a storage rot of sweet potatoes in Trinidad.

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THE HOST PLANTS OF FOMES ANNOSUS.

By Malcolm Wilson.

The Red Rot or Heart Rot caused by *Fomes annosus* has been long recognised in this and in other countries of Western Europe as one of the most important diseases of conifers. In this country the disease has assumed increasing importance during recent years on account of the extensive schemes of afforestation which are being carried out, and any facts regarding its distribution and biology are consequently of importance.

In this country M. L. Anderson (1, 2) has recently recorded its occurrence on the following coniferous species: *Pinus sylvestris*, *Picea excelsa*, *P. sitchensis*, *Larix europaea*, *L. leptolepis*, *Tsuga albertiana*, *Abies grandis*, *Thuya gigantea* and *Pseudotsuga Douglasii*.

To this list must be added *Pinus Laricio*, *Abies nobilis* and *A. pectinata*, and it appears probable that all coniferous species may be attacked. It has not been observed on *Pinus Strobus* in this country but has been recorded on this species by Hartig (3) and on *Abies balsamea* by Tubeuf (11). Its occurrence on *Juniperus communis* also has been reported by Hartig ((3), p. 186) in Germany, and recently the fungus was found attacking this species in Scotland.

Fomes annosus appears to be chiefly a European species, for although it has been recorded in North America on *Pinus monticola* and other conifers, its occurrence there appears to be unusual and it does not seem to be of any importance as the

cause of disease in the United States (8, 10, 12). Practically all the American conifers that have been introduced into this country have been seriously attacked by the disease, and the fact may perhaps be explained on the supposition that the American fungus differs at least physiologically from the British species.

There is no doubt that *Fomes annosus* does occur on a considerable number of dicotyledonous trees and shrubs but its distribution on these hosts appears to differ considerably in the different countries of Europe. Lind ((5), p. 386) in Denmark records it on eleven dicotyledonous species including *Quercus Robur, Fraxinus excelsior, Fagus sylvatica, Betula alba, Prunus avium, Pyrus Aucuparia, Ulmus montana* and *Calluna vulgaris*. On the other hand, Lagerberg (4) states that he has been unable to find any attack on dicotyledonous trees in Scandinavia. In Germany, however, it has been recorded on *Betula alba* (3), *Corylus Avellana* and *Alnus glutinosa* ((9), p. 61), *Acer* sp. ((7), p. 422) and on *Fagus sylvatica* and *Crataegus Oxyacantha* ((11), p. 450), while Prillieux ((6), T. 1, p. 325) mentions it on five dicotyledonous species including *Quercus Ilex*, although it is not clear that his list refers especially to France. It has been collected on various deciduous trees in North West America (12).

Its distribution on dicotyledons in Scotland appears to be fairly similar to that in France, Germany and Denmark; it has been found on the following species: *Fagus sylvatica, Betula alba, Corylus Avellana, Alnus glutinosa, Prunus Padus, Pyrus Aucuparia, Pyrus Aria, Crataegus Oxyacantha* and *Rhododendron ponticum* var. Up to the present it has not been found on *Calluna vulgaris* in this country and this fact may be of importance, especially in Scotland where heather is found over wide areas which are suitable for afforestation. Its occurrence on *Rhododendron ponticum* which is so commonly found in plantations may be also a fact of considerable significance.

The importance of the occurrence of *Fomes annosus* upon angiosperms rests on the assumption that the fungus from them can infect conifers. No experimental work appears to have been carried out on this point and until it is done the question must be left open.

It is well known that coniferous plantations formed on what was previously arable ground are often severely attacked by *Fomes annosus* and the origin of the fungus in these cases has been somewhat difficult to explain, especially when the plantations are at some distance from other coniferous woods. The fact that the fungus can grow on a number of dicotyledonous trees, among which are several common hedgerow species, seems to offer a possible explanation. Its occurrence on oak and birch

may explain the frequent appearance of the disease when scrub areas, covered by these species, are cleared and planted up with conifers.

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THE RATE OF GROWTH OF LICHENS.

By L. Porter, M.Sc., University College, Cork.

RECENT work on the rate of growth of lichens has been summarised by Miss Lorrain Smith in the *Transactions* for 1923 and 1925. Linkola's work on species of *Parmelia*, growing on palings, showed the average rate to be 1 mm. per annum. This is exceeded by *P. centrifuga* on rocks, with a rate of 2·5 mm. per annum.

From these measurements the ages of different specimens were deduced, *e.g. P. sulcata*, 30–40 years; *P. centrifuga*, 50–80.

On the other hand, Tobler, in examining species of *Cetraria* on beech and spruce, found that the rate of growth was 1 cm. per annum.

Miss Lorrain Smith points out that Tobler was dealing with young plants, often composite forms from the mingling of

individuals of soredial origin; while Linkola investigated plants that were well established.

The natural conclusion is that rapid growth may occur in young states and favourable circumstances but that it is usually followed by slower growth when a large area has been covered or conditions have become unfavourable.

It would therefore be impossible to deduce the age of any specimen from its measurements since even when the maximum area has been covered a lichen may continue to live by balancing its gonidial and fungal activities, resulting in increase of thickness or development of thalline, soredial or isidial outgrowths. Further, we have as yet few observations on the time required for the development of fructifications.

In lichens on gooseberry bushes the limits of age are easily determined, either from the known age of the bush or the dates of pruning.

Two varieties of gooseberry were recently under observation. One, which naturally and by pruning had chiefly upright branches, was singularly free from lichens. The bark was smooth but powdered with algal forms and occasional soredia. The only lichen on this variety was *Physcia stellaris*. It invariably occupied the angle between two or more branches, *i.e.* the best position for horizontal exposure and the retention of moisture enabling the spores to germinate.

The second variety formed a spreading head of more or less horizontal branches and had a rougher bark. It is constantly being colonized from the adjacent apple and cherry trees. One such bush in its seven years of life, even with two perfunctory prunings, had acquired a large collection of lichens. The following list gives the measurements of its largest specimens:

Ramalina fraxinea Ach.—20 mm. in length.
Parmelia caperata Ach.—50 mm. along a twig.
,, *subaurifera* Nyl.—30 mm. along a twig.
,, *perlata* Ach.—50 mm. × 40 mm. axillary.
,, *sulcata* Tayl.—20 mm. along a twig.
Physcia stellaris Nyl.—28 mm. axillary.
P. stellaris vars. *tenella* and *leptalea*—young, axillary.
Lecidea parasema Ach.—13 mm. round a twig.
Physcia stellaris and *Lecidea parasema* had well developed apothecia.

Other gooseberry bushes provided *Evernia prunastri* Ach. and *Usnea hirta* Ach. *U. florida* Web. does not occur in the neighbourhood.

Graphis and allied species were absent, although plentiful on neighbouring sweet briar and hawthorn. This might be due to their preference for a smoother bark, coupled with the fact that the algal forms on the smooth-barked gooseberries did not include *Trentepohlia*.

Red currant bushes of about the same age are mingled with the gooseberries. They provided *Physcia stellaris, Parmelia caperata, P. subaurifera, Ramalina fraxinea, Lecidea parasema, Biatorina premnea* and *Xanthoria parietina.*

Black currant of less luxuriant growth had only *Physcia stellaris* and *Lecanora subfusca.* The young forms of *Physcia* were of interest as they showed that *Ph. tenella* is distinguishable in its earliest infancy from *Ph. stellaris.* In several instances two thalli crowded together were not only distinguishable but easily separable, which is not so with *Ph. tenella* and *Ph. leptalea,* since the hooded and the flattened tips appear together on the same plants at early and late stages. Large specimens of the same plant from palings near the sea, west of Kinsale, Co. Cork, show such strong divergence from the *stellaris* type as to favour separation as the *Physcia hispida* Tuckerm.

The most striking development of lichens is attained by plants which have grown in the angles made by two or three branches, a favourite position for *Parmelia perlata* and *Physcia stellaris. Parmelia sulcata* can exist similarly, but *P. caperata* must be closely pressed to the surface, and when it has encircled a twig it extends longitudinally. The specimens of *P. perlata,* measured above, had reached the largest size consistent with its position. The three unattached edges had continued their activity by a large development of the characteristic undulations with sorediate surfaces.

The preference of lichens for horizontal exposure is due to the dimmer light of this moist climate and to the longer retention of moisture on the horizontal plane.

Miss Lorrain Smith describes the work of Plitt on the lichens of Jamaica. He concluded that light was the most important factor in their existence. When he further studied the lichens of Maine, endeavouring to correlate the evaporating power of the air, the intensity of light and the distribution of lichens up and around a tree, he decided that evaporation was the determining factor. This apparent contradiction may be due to differences in climate between Jamaica and Maine. As a rule, the greater the illumination the greater is the evaporation. But in a moist climate such as that of the south-west of Ireland, lichens certainly flourish best where exposed to the greatest illumination, which for gooseberry bushes is on the horizontal branches. In trees, such as apple and cherry, the uppermost and outermost branches are most richly covered with lichens, and for larger trees, such as beech, an exposed trunk is the favourite habitat, but if the trunk is short or shaded by branches leprous forms are abundant, but there is no great development of lichens until the trunk has reached considerable size. Several

very high beech trees, more than 150 years old and which were unbranched for 30 feet or more were examined. The branches had developed on the southern and western sides in spite of the prevalent south-westerly gales, consequently the northern side had the greatest illumination and was covered with lichens, especially *P. caperata*. The largest specimen of this species which had probably developed from a single centre during the last 100 years had an area of about 80 sq. cm., indicating a rate of growth comparable with an advance of 1 cm. per annum.

ON SPECIES OF THE GENUS NIGROSPORA ZIMMERMANN RECORDED ON MONOCOTYLEDONS.

(With Plate XV.)

By E. W. Mason, M.A., M.Sc., Imperial Bureau of Mycology.

Introduction.

In 1921 a number of specimens from Uganda were received at the Imperial Bureau of Mycology for determination; among these was a black-spored Hyphomycete on rice, which was recognised to be the fungus known at Pusa, India, as *Epicoccum hyalopes* Miyake (Fig. 6). In 1924 Petch redescribed *Monotospora Oryzae* B. and Br. on the same host, and referred it to Zimmermann's genus *Nigrospora* as *N. Oryzae* (B. and Br.); specimens of this were received shortly afterwards from the Gold Coast, W. Africa, and on revision it became clear that *Nigrospora Oryzae* and *Epicoccum hyalopes* were very closely related if not identical fungi. A very similar organism was shortly afterwards observed on maize leaves from the Gold Coast for which a host index suggested the name of *Coniosporium Gečevi* Bubák (Fig. 5). An isolation from banana fruits (Fig. 3) received from the West Indies, again gave a similar fungus which in culture suggested Molliard's species *Basisporium gallarum* (Fig. 1), and was also reminiscent of Cavara's picture of his *Acremoniella occulta* (Fig. 7).

The systematic position of these closely related organisms became no clearer when Miss Dale's culture of *Basisporium gallarum* Moll. from the Centraalbureau voor Schimmelcultures was examined. It was found not to be a similar organism at all.

It is inconvenient to be compelled to look for closely related species in such diverse genera and an attempt is here made to bring together a number of these congeneric species recorded on Monocotyledons. So far as may be possible at a first attempt,

I have sorted them out into their apparent morphological species.

Basisporium gallarum Moll.

Molliard in May 1902 described and figured *Basisporium gallarum* (No. 20)* gen. nov., spec. nov., on a fungus growing on dead larvae of *Lipara lucens* found in some galls on *Phragmites communis* in France; the fungus was described from cultures. The essentials are as follows:

It grew rapidly on nutrient media, especially nitrogenous ones; the hyphae are at first hyaline, but the sterile ones quickly turn brown and attain a maximum diameter of 18μ; the fertile hyphae only slowly turn brown, are of a diameter of 4μ, and bear terminally and laterally "basidia ampullifera," *i.e.* squat inflated vesicles, on which the spores are borne singly. The spores (Fig. 1) become black and quite opaque. They are round when seen from the apex but in side view are rather pointed at the top and flattened at the base. They show very little variation in size and measure 14μ in long diameter, *i.e.* across the poles, and 11μ in short diameter, *i.e.* in the axis of the poles.

In 1912 Miss Dale, who was isolating soil fungi at Woburn, England, recorded doubtfully, *Basisporium gallarum*; she deposited her culture at the Centraalbureau voor Schimmelcultures, where it is still maintained, and from which, as mentioned above, a subculture was obtained and examined. The hyphae are hyaline, rather narrow and diffluent; the spores are a lightish brown and remain transparent; they are borne directly on the hyphae or on short pedicels. They are generally round from every view point (*i.e.* globose) (Fig. 2 *a*); they are sometimes elongated in the direction of the main axis and very occasionally become uniseptate (Fig. 2 *b*).

This agrees fairly well with Miss Dale's description, although she says that the spores are deep brown or black. An original slide of this culture is preserved at the British Museum and I have examined it through the courtesy of Mr Ramsbottom. It shows that the present culture has not changed materially since 1912. It does not, however, belong to Molliard's genus as here understood.

I have seen no other published records of *Basisporium gallarum* for Europe. In July, 1926, however, Dr Peyronel, of the Statione di Patologia Vegetale, Rome, kindly forwarded me specimens which he had determined as *B. gallarum* (No. 20 B) in wheat culms from Piedmont, Italy. The specimens were growing among insect eggs and detritus. I have no doubt at all that the specimens were correctly determined.

* For numbers after specific names, see table on pp. 154–155, col. 2.

LIST OF RECORDS OF *NIGROSPORA* SPP. ON MONOCOTYLEDONS, WITH THE MEASUREMENTS OF THE LONG AXIS OF THE SPORE IN μ.

(Names in italics are not certainly referable to *Nigrospora*.)

Host	No.	Fungus, name and authority	Date	Origin of material examined	Diagnosis	No. of spores measured	10μ	11μ	12μ	13μ	14μ	15μ	16μ	17μ	18μ	19μ	20μ	21μ	22μ	23μ	24μ
Maize	1	*Sporotrichum Maydis* Garov.	1873	No type material in existence	14 to 15·5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	1 B	Trichosporium Maydis Sacc.	unpubl.	Ex Mycotheca Saccardiana, Trotter 1911	.	50	.	.	1	17	25	4	3	.	.	.	.	.	.	.	.
	2	Trichosporium sphaericum Sacc.	1882	Ellis, North American Fungi, No. 968 in Herb. Kew	16 to 18	50	.	.	.	.	.	3	9	15	22	1	.	.	.	.	.
	4	*Monotospora nigra* Morgan	1895	None examined	14 to 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	5	*Mycogone nigra* (Morgan) Jensen	1912	ditto	12 to 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	6	Coniosporium Gečevi Bubák	1912	ditto	15 to 20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	7	Coniosporium Gečevi Sacc.	1912	ditto	13 to 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	Basisporium gallarum Durrell	1925	ditto	13 to 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	—	unpubl.	C.B. 231 on maize leaves from Gold Coast	.	25	.	.	.	.	.	1	7	5	10	.	2	.	.	.	.
	10	—	unpubl.	Slide of cultures isolated from same	.	50	.	.	.	.	2	3	7	9	14	7	6	1	1	.	
	11 B	Nigrospora javanica Palm	1918	—	22 to 30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rice	1 A	*Sporotrichum Maydis* Garov.	1874	—	14 to 15·5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	12	Monotospora Oryzae B. and Br.	1873	Type material in Herb. Kew	12·5 to 15	100	.	1	10	34	36	13	6	.	.	.	.	.	.	.	.
	12 A	Nigrospora Oryzae (B. and Br.) Petch	1924	Co-type material at Peradeniya	9 to 16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	12 B	Nigrospora Oryzae I. B. M.	1924	Gold Coast, C.B. 103. Slide of portion of a rice leaf	.	50	1	0	0	10	25	13	0	0	1	.	.	.	.	.	.
	12 C	—	unpubl.	Philippine material found in Baker, Fungi Malayana 218 in Herb. Kew	.	25	.	1	1	3	14	6	.	.	.	.	.	.	.	.	.

	13	Epicoccum hyalopes Miy.	1910	None examined	14 to 18 (by 13 to 15)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	13 A	Epicoccum hyalopes I. B. M.	unpubl.	Uganda from J. D. Snowden, No. 678	.	50	.	.	.	.	.	2	9	12	17	9	1	.	.	.
Sugar-cane	14	Epicoccum levisporum Pat.	1893	Type material examined	15	50	.	.	.	.	1	4	12	9	22	2	.	.	.	.
	15	Coniosporium extremorum Syd.	1913	ditto	13 to 20 (or 15 to 20 × 12 to 17)	50	.	.	.	1	3	2	17	18	8	1	.	.	.	.
	16	Glenospora Sacchari Speg.	1896	ditto	20 to 22 × 15 to 18	50	.	.	.	.	.	.	1	0	4	9	13	11	6	3
	17 C	—	unpubl.	Also present on type material of last species	.	50	.	.	2	7	29	11	1	.	.	.	.	.	.	.
	17 D	—	unpubl.	Culture isolated by E. F. Shepherd, Mauritius	.	75	.	2	5	16	34	14	5	.	.	.	.	.	.	.
	17 B	Acremoniella occulta Ashby	unpubl.	On leaf spot, Barbados from S. F. Ashby	.	37	.	2	7	10	11	6	1	.	.	.	.	.	.	.
Coco-nut	18	Memnonium palmicolum Cke.	1877	Type material in Herb. Kew	15	50	.	.	.	2	14	21	13	.	.	.	.	.	.	.
Coco-nut and banana	17 A	Acremoniella occulta Ashby	1913	None examined	13 to 15·5 × 10 to 13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	22	—	unpubl.	Isolated from banana fruits and also leaf bases, W. Indies	.	50	.	.	.	.	1	2	13	14	20	.	.	.	.	.
Arundo conspicua	19	Hadrotrichum arundinaceum Cke. and Mass.	1887	Type material in Herb. Kew	30μ	50	.	.	.	.	1	0	7	10	17	10	5	.	.	.
Arundo Phragmites	20	Basisporium gallarum Moll.	1902	None examined	14 × 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Panicum amphibium	21 A	Nigrospora Panici Zimmerm.	1907	ditto	25 to 30 × 22 to 25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	21 B	Nigrospora Panici Kuyper	unpubl. (?)	Culture from Centraalbureau (host not stated)	.	50	.	.	1	2	7	4	9	6	16	3	2	.	.	.
Wheat	11 A	Nigrospora javanica Palm	1918	—	22 to 30	.	.	.	.	.	.		.	.	.	.	.	.	.	.
	17	Acremoniella occulta Cavara	1893	—	13 to 15 × 9 to 12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	20 B	Basisporium gallarum Peyronel*	unpubl.	Received from Italy July 1926	.	50	.	.	3	20	24	3	.	.	.	.	.	.	.	.
Gynerium	23	Coniosporium micans Gaja	1912	None examined	18 to 20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

* This specimen has since been accepted by Prof. Cavara as his *Acremoniella occulta*.

The genus *Nigrospora*.

Some months before Molliard's paper was published, Zimmermann in Java (February, 1902) had established the genus *Nigrospora* on *N. Panici*, spec. nov., growing on the leaves of *Panicum amphibium* (No. 21 A and Fig. 8). He describes and figures a typical *Basisporium* apparatus protruding through a stoma; the black opaque spores are borne singly on a short dark grey conidiophore (*i.e.* the vesicle) and both are surrounded by a hyaline layer, which is no doubt the mucus covering which sometimes in culture may be seen dripping from the spore. The spores measured 25 to 30μ × 22 to 25μ, being larger than any I have verr met. There would appear to be no question but that Zimmermann was dealing with an organism strictly congeneric with Molliard's *Basisporium gallarum*. He was not successful in getting his species into culture. Recently a culture received from the Centraalbureau voor Schimmelcultures labelled *Nigrospora Panici* (No. 21 B), and isolated by Kuyper, proves to be a typical *Basisporium*; whether it represents Zimmermann's species is not quite certain; its host is not stated and the spore measurements are considerably less. *Nigrospora* is accepted in the present paper as the correct generic name to which these species should be referred.

The results of examining a number of collections of these species are given in the table on pp. 154–155. The long diameter of a number of spores was measured in each case to the nearest micron; the short diameter of an opaque spore cannot be so readily measured and appears to be an unsuitable character for tabular presentment. In material of any age, the spores seen from the side appear to be quite elliptical in optical section; and in the larger spored strains I have not observed that the apex is ever distinctly pointed.

Nigrospora on Banana and Coco-nut.

Two isolations from West Indian banana plants, one from the fruit and one from the petioles, made at the Imperial Bureau of Mycology, gave the same species of *Nigrospora* (No. 22, Fig. 3). The great mass of conidia showed in their long diameter a range of 16 to 18μ.

In 1913, Ashby determined a fungus on banana and coco-nut leaves in Jamaica as *Acremoniella occulta* Cavara (No. 17 A and Fig. 4); his figure shows that he was dealing with a *Nigrospora*, and a later determination by him of *Acremoniella* on sugar-cane (No. 17 B) from Barbados which he has kindly allowed me to examine, confirms this view. The spore measurements given were 13 to 15·5μ × 10 to 13μ.

Later, a culture was received of *Nigrospora* (No. 17 D),

isolated by E. F. Shepherd of Mauritius from sugar-cane. The mass of its spores showed a long diameter of 13 to 15μ, thus agreeing with Ashby's figures for his banana and coco-nut fungus and, incidentally, well enough with Molliard's description of *Basisporium gallarum*. In the two cultures under observation, the two mean spore sizes have shown no tendency to run into one another, which seems to show that there are two distinct strains, if not indeed species, of *Nigrospora*, and that both occur on the banana plant. As will appear, the same two strains seem to be indicated also on maize, rice and sugar-cane. For reasons which will be given later, the larger spored strain is referred to *N. sphaerica* and the smaller spored strain to *N. Oryzae*.

In 1887, Cooke shortly described *Memnonium palmicolum* (No. 18) on coco-nut leaves from Demerara, British Guiana. The type specimen shows that it is a *Nigrospora*. It belongs to the *N. Oryzae* group, but has a considerable number of spores with a diameter of 16μ. Saccardo (1886) lists the fungus as *Trichosporium palmicolum* (Cke) Sacc.*

Nigrospora on Maize.

About 1870 an idea was current in Italy that "pellagra" was due to excessive eating of foods prepared from maize, especially when the latter had been subjected to fungus attack. A doctor forwarded a sample to Pavia for examination and in 1874 Garovaglio, the Director, published a report. The grain had been damaged in the field by hail, and was cracked and variously distorted. A black spored fungus (diam. 14 to 15·5μ) was found growing on the grain at the points of damage, especially where the endosperm was cracked. It was named *Sporotrichum Maydis* (No. 1), in Rendic. R. Ist. Lomb. ser. 2. vi (1873), p. 242.

Saccardo (1886) listed the fungus as *Trichosporium Maydis* (Garov.) Sacc., and Ferraris (1910) as *T. Maydis* (Cattan.) Sacc. Both refer to the same fungus. From the original description and figure of the fungus, I do not think that it can be referred with any certainty to *Nigrospora*. Professor Montemartini informs me that no type material is available at Pavia. So far as I can find out, the first specimen referred to this species and now in existence, was collected in Avellino, Italy, by Professor Trotter in July, 1911 (No. 1 B); I am informed that it was studied by Saccardo in whose herbarium it now remains. Through the courtesy of Professor Gola, a small sample, consisting of two maize grains, has been examined. The outer skin of the grains is broken and the fungus is growing through the

* *Trichosporium* Fr. was emended by Saccardo and is now a very composite genus. No Friesian species are known. According to von Höhnel (1923), *Memnonium* Corda is really the correct generic name for *Stachybotrys* Auct. non. Corda.

endosperm. It is a *Nigrospora* of the small spored type, and appears to me exactly similar to *Nigrospora Oryzae* (B. and Br.) Petch, authentic material of which dates back to 1873.

Trichosporium Maydis was also recorded by Montemartini (1925) on maize grains in Padua; but I have had no opportunity of examining it. Unless authentic material of this species can be found it would appear to be well to let the name lapse.

Meanwhile, Ellis had sent a large batch of fungi from New Jersey, U.S.A. to Saccardo who (1882) shortly described a black spored fungus (16 to 18μ diam.) on maize culms as *Trichosporium sphaericum* (No. 2). Ellis issued an exsiccatum in his North American Fungi, No. 968. The specimen in Herb. Kew corresponding to the diagnosis is a species of *Nigrospora* and gives a basis for the earliest known specific name of the larger spored group. As Table I shows, the Gold Coast specimens C.B. 231 (Nos. 9 and 10) on maize leaves agree with the spore measurements of this species, which is accordingly called here *N. sphaerica* (Sacc.) comb. nov.

In 1895 Morgan founded *Monotospora nigra* (No. 4) on a black spored form on maize stalks in Ohio, U.S.A.; but the publication has not been seen nor are specimens available. Morgan's description as given by Saccardo (*Syll.* XIV, p. 1075) suggests *Nigrospora*. In 1912 Jensen, at Cornell, repeatedly isolated from the soil of maize fields a fungus which he identified as Morgan's species. He considered that the fungus had two-celled spores, the upper cell dark brown, smooth, thick-walled globose; the lower cell hyaline to slightly coloured, smooth, hemispherical. He referred it to *Mycogone*, as *M. nigra* (Morgan) Jensen (No. 5). I regret that I have not been able to learn anything about this species.

In 1909, Heald and Pool in Nebraska, U.S.A., were examining "moldy corn," and from it isolated *Melanospora pampeana* Speg. In culture this was found to form perithecia freely if grown with, or following, certain maize cob fungi of which *Basisporium gallarum* was the most satisfactory*.

In 1912, Bubák examined some maize cobs received from Bulgaria and found the axis infested with a black spored fungus which he named *Coniosporium Gečevi* (No. 6 and Fig. 5); he did not have the opportunity of determining whether or not it was parasitic.

Meanwhile, in 1911, there had been trouble with stored maize grain in Ohio, U.S.A., the state where Morgan had worked. The investigation was entrusted to Arzberger, who reported in 1913. He found a black spored fungus permeating the tissue of

* What is apparently the same *Melanospora* appeared on banana plants at the Imperial Bureau of Mycology in 1924 and 1925 among a number of other fungi. It formed abundant perithecia in culture following a species of *Fusarium*.

the cob and isolated it repeatedly. He determined that it was a *Coniosporium*, and sent specimens to a number of systematists, including Saccardo, and Bubák. Bubák stated that it was the same as his *Coniosporium Gečevi* and forwarded some of his own material in support of this assertion. Saccardo (1912) at first stated that it was a new species of *Coniosporium*, but later confirmed Bubák's opinion. His own point of view, I think, emerges from his note (*loc. cit.*). In Bubák's diagnosis, the spore diameter is given as 15 to 20μ. Saccardo states that *C. Gečevi* (No. 7) differs from *Coniosporium micans* Gaja on *Gynerium* in the spore diameter being 13 to 15μ, as opposed to 18 to 20μ, and in occurring on the caryopses and not on the culms. Arzberger's general conclusion was that the fungus grew as a saprophyte in the tissues of the cob after maturity, usually appearing while the corn was in stook.

In 1918 Palm noted that the Javanese fungus *Nigrospora javanica* Zimmerm. (No. 11 B) occurs on maize and rice as well as on wheat. It may be noted that Palm intended to cite *N. Panici* Zimmerm. which is the only combination in this genus which Zimmermann made. A culture received from the Centraalbureau labelled *N. javanica* proved to be a very poorly sporing strain of *Nigrospora* and, as mentioned above, a second strain, labelled *Nigrospora Panici* (No. 21 B), was a freely sporing and typical *Nigrospora* as here understood.

In 1922 Ramsey described and figured *Basisporium gallarum* as causing a rot of tomatoes and stated that *Basisporium* had been isolated from several sources including maize. Following this paper, the *Coniosporium Gečevi* of Ohio was determined as *Basisporium gallarum* (No. 8) and in 1925 Durrell published a progress report on the damage which the fungus does in the State of Iowa. The shank of the maize is attacked and so retted that the ear may fall off at harvest. In the tissue of the ears the fungus grows luxuriantly and the kernels become loose and the fungus may be found fruiting in the kernels. Sometimes the embryo itself is invaded. There is a very marked relationship between humidity and the occurrence of *Basisporium* disease. From Durrell's account it is quite certain that he was dealing with a *Nigrospora*.

As already stated, material of both the large spored group of *Nigrospora* (Nos. 2, 9 and 10) and of the small spored group (No. 1 B) has been examined. Consideration of the other records affords evidence that the two groups have already been differentiated on maize. *Coniosporium Gečevi* (No. 6) was described by Bubák as being 15 to 20μ in diameter; by Saccardo (No. 7) from material from Bubák and the U.S.A. as 13 to 15μ. There is the hypothetical case of *Monotospora nigra* Morgan (No. 4) (14 to

18μ) and *Mycogone nigra* (Morgan) Jensen (No. 5) (13 to 15μ), and the *Sporotrichum Maydis* of Garovaglio and Cattaneo, which, if it was a *Nigrospora* at all, belonged to the small spored group.

Nigrospora on Rice.

In 1874 (No. 2) Garovaglio recorded his *Sporotrichum Maydis* (No. 1 A) on rice glumes in Italy, and this was confirmed by Cattaneo in 1877. The fungus does not appear to have been recognised on rice since that date, though von Thümen (1889) and Miyake (1910) carry it forward in their list of rice fungi.

In 1873 however Berkeley and Broome shortly described *Monotospora Oryzae** (No. 12) on rice leaves from Ceylon with a spore diameter of 12·5 to 15μ. It does not appear to have been recognised again until Petch drew attention to it in 1924. He considered it was not a good *Monotospora* and refers it to Zimmermann's genus *Nigrospora* as *N. Oryzae* (B. and Br.) Petch (No. 12 A). He had found it recently in quantity on rice suffering from "Senthal" (red-stalk), but it was not considered the cause of the disease. The type specimen in Herb. Kew shows it to be a good *Nigrospora* as here understood, and as it is the first species of which authentic material is in existence, I think that it must be called *N. Oryzae* (B. and Br.) Petch. As Table I shows, it belongs to the smaller spored group, to which it gives its name. The Gold Coast specimen C.B. 103 (No. 12 B) is the same, and I have also found it on Philippine material of rice (No. 12 C), included in Baker, *Fungi Malayana*, No. 218, labelled *Coniosporium oryzinum* Sacc.†

In 1910 Miyake described and figured *Epicoccum hyalopes*‡ (No. 13, Fig. 6) on rice glumes in Japan. The spore measurements are given as 14 to 18μ × 13 to 15μ. I have not seen any authentic material, but it seems undoubtedly to be a *Nigrospora*. Material from Burma has been recognised as this species at Pusa (Butler, 1913) and it is also recorded for Uganda. The Uganda specimens from Snowden (No. 13 A) are *Nigrospora* and referable to *N. sphaerica*.

* The type species of *Monotospora*, *M. toruloides* Corda, is now unknown. Berkeley and Broome conceived the genus as characterised by differentiated conidiophores (of the *Helminthosporium* type) bearing single black spores. Their earliest species are not known in culture.

† Saccardo's species (1916) is a *Coniosporium* of the *C. Arundinis* type. This type forms a well-marked group in the genus *Coniosporium*; it is referred by Grove to *Melanconium*; by von Höhnel to Fries' old genus *Papularia*, and in culture is apparently the same as Tengwall's genus *Pseudobasidium*. It is very inconvenient to have this group of *Coniosporium* mixed up indiscriminately with *Nigrospora* spp. in the genus *Coniosporium*. The majority of species referred to *Coniosporium* which are recorded on Monocotyledons belong to this group.

‡ The better known species of *Epicoccum*, *e.g. E. neglectum* on maize are quite diverse from *Nigrospora*.

So of the four collections of *Nigrospora* on rice examined by the author, three fall into the *N. Oryzae* group and one into the *N. sphaerica* group.

Nigrospora on Sugar-cane.

In 1893 Patouillard described *Epicoccum levisporum* (No. 14) on the leaves of sugar-cane at San Nicolas, S. America, and by his courtesy the type specimen has been examined, and is undoubtedly *Nigrospora*. In 1913, Sydow described *Coniosporium extremorum* (No. 15) on leaves of sugar-cane from the Philippines. A portion of the type specimen was kindly given me by Professor Samuelson of the Riksmuseets, Stockholm. It is a *Nigrospora*. These two collections are identical and fall within the *N. sphaerica* group.

In 1896 Spegazzini described *Glenospora Sacchari** (No. 16) on sugar-cane at Tucumán, La Plata. He very kindly lent me this collection with its original envelope, on which he has figured a typical *Nigrospora*. He gives the spore measurements as 20 to $22\mu \times 15$ to 18μ, and my measurements on three preparations confirm these figures, which indicate a larger form than we have yet met with. A fourth preparation, however (No. 17 c), gave me the *N. Oryzae* form, which matches Shepherd's culture (No. 17 D) from sugar-cane. It is also matched by a fungus on some pickled material of *Phyllosticta* leaf spot of sugar-cane from Barbados which was given me by Mr Ashby as a sample of his *Acremoniella occulta* (No. 17 B)†.

In 1917 Johnston and Stevenson recorded *Basisporium gallarum* on sugar-cane in Porto Rico, but no spore measurements are given. They write: "This is one of the very common saprophytic forms encountered in the work with cane fungi, it being found on all parts of dead and dying plants after forming black, irregular patches, especially on leaves and dead seed pieces. It has turned up in culture several times, in one instance of a top rot case and of various leaf spots, but inoculations with it have not been successful. It also occurs on other grasses *Panicum barbinode, Eriochloa subglabra*."

Of the seven specimens of *Nigrospora* examined by the author on sugar-cane, four are referable to *N. Oryzae*, two to *N. sphaerica* and one, *Glenospora Sacchari*, is a very large spored form which, although it is not known whether it will be distinguishable in culture, it appears best to distinguish for the time as *N. Sacchari* (Speg.) comb. nov.

* The type species of the genus *Glenospora* is *G. Curtisii* Berk. and Desm. This species is not properly understood, but it is not a *Nigrospora*.

† A collection on sugar-cane from Uganda, just received, is also referable to *N. Oryzae*.

Nigrospora on other hosts.

In 1893 Cavara, working at Pavia, described and figured *Acremoniella occulta** (No. 17, Fig. 7) on culms from a cornfield near Florence, Italy. Later writers agree in stating that the host plant was wheat. The spore measurements are given as 13 to 15μ × 9 to 12μ. As his figure shows, the spores resemble *Nigrospora* spores and the measurements agree with those of *N. Oryzae*. It is hard to believe that Ashby's determination (No. 17 A) of this fungus is not correct. There is, however, no authentic material of this fungus at Pavia, and it is perhaps better not to cite the fungus as certainly *Nigrospora*†. Stevenson (1926) states that the fungus occurs on wheat and rye in Great Britain and Italy, but I have not traced his authorities for this statement. The only other record of a *Nigrospora* on wheat that I have is Palm's record of *Nigrospora javanica* causing a glume spot of wheat.

In 1887 Cooke and Massee described *Hadrotrichum arundinaceum*‡ on *Arundo conspicua* at Kew, England (No. 19), and in 1893 Massee published a small figure, which does not bring out the essential characters. The diagnosis gives the spores as sub-globose and 30μ in diameter; but although the type specimen in Herb. Kew shows that the fungus is a *Nigrospora*, I have found no spores approaching 30μ in diameter; on the contrary, morphologically this fungus falls into *N. sphaerica*.

Coniosporium micans Gaja (1912), on *Gynerium* in a cool house in Italy, is only mentioned here because of Saccardo's statement (1912) that it is similar to *C. Gečevi*§.

* The type species of *Acremoniella* is *A. atra* Sacc. *Nigrospora* has little in common with this species.

† Dr Peyronel points out that his specimen of *Basisporium gallarum* on wheat culms from Piedmont, Italy, agrees exactly with the measurements given by Cavara for *A. occulta* (see p. 153).

Since the above was written it has been found possible to submit to Professor Cavara the specimen No. 20 B on wheat culms from Italy, which was received from Dr Peyronel determined as *Basisporium gallarum* Moll. and queried as *Acremoniella occulta* Cavara. Professor Cavara agrees that this specimen represents his species, which accordingly falls into *Nigrospora Oryzae* (B. and Br.) Petch; it should be stated, however, that Professor Cavara was not satisfied that his species and *Basisporium gallarum* Moll. were the same thing.

‡ At this date, the type species of *Hadrotrichum*, *H. Phragmitis*, was confused with *Napicladium arundinaceum*. The most commonly copied picture of the former is considered to represent really the conidiophores of the latter turned upside down.

§ I have no evidence that *Coniosporium micans* is a *Nigrospora* although the diagnosis strongly suggests it. On the need for caution, compare Saccardo's footnote on *Trichosporium insigne* Mass. and Salm. (*Syll.* XVIII, p. 574), "A *T. sphaerica* Sacc. hyphis hyalinis et conidiis verruculosis differt." The chief resemblance is that the respective authors of these two species have each referred his species to the genus *Trichosporium*.

Glenospora elasticae Koorders (1907) (Fig. 9) on *Ficus elastica* from Java is, from its figure and description, clearly a *Nigrospora*. Its spore measurements are said to be 14 to 16μ × 12 to 12·5μ. It is mentioned here as it is the only *Nigrospora* that I have found with a figure published under the name of *Glenospora*. There is no authentic material at Berlin, and unless a slide is preserved at Java, probably none is in existence.

CHRONOLOGICAL LIST OF SPECIES OF *NIGROSPORA*.

(Species in italics not known to me and doubtful species of *Nigrospora*.)

	Name	Suggested name
1873	*Sporotrichum Maydis* Garov. [*Trichosporium Maydis* (Garov.) Sacc.]	? N. Oryzae
1873	Monotospora Oryzae B. and Br. [Nigrospora Oryzae (B. and Br.) Petch]	N. Oryzae
1877	Memnonium palmicolum Cke. [Trichosporium palmicolum (Cke.) Sacc.]	N. Oryzae
1882	Trichosporium sphaericum Sacc.	N. sphaerica
1887	Hadrotrichum arundinaceum Cke. and Mass.	N. sphaerica
1893	Epicoccum levisporum Pat.	N. sphaerica
1893	Acremoniella occulta Cav.	N. Oryzae
1895	*Monotospora nigra* Morgan	(?) N. sphaerica
	[*Mycogone nigra* (Morgan) Jensen]	(?) N. Oryzae
1896	Glenospora Sacchari Speg.	N. Sacchari
1902	Nigrospora Panici Zimmerm.	Nigrospora sp.
1902	Basisporium gallarum Moll.	N. Oryzae
1907	Glenospora elasticae Koorders	N. Oryzae
1910	Epicoccum hyalopes Miyake	N. sphaerica
1912	Coniosporium Gečevi Bubák	N. sphaerica
1912	*Coniosporium micans* Gaja	(?) Nigrospora sp.
1913	Coniosporium extremorum Syd.	N. sphaerica
1918	Nigrospora javanica Palm	Nigrospora sp.

SUMMARY.

A number of records of black spored Hyphomycetes occurring on Monocotyledonous hosts are referable to the genus *Nigrospora* Zimmermann (Synon. *Basisporium* Molliard). Spore measurements indicate that three species may be provisionally accepted. There is, at the moment, no evidence that the different strains can be classified by the host on which they occur or by their country of origin.

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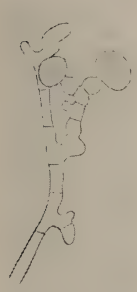
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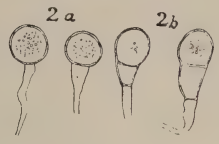

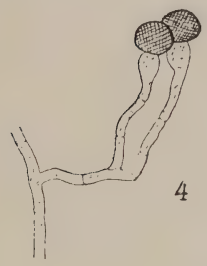
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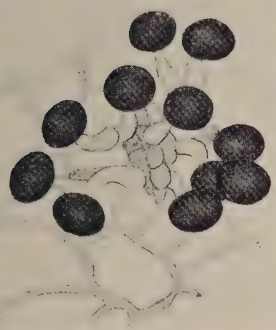

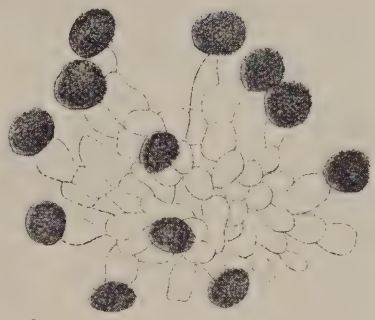
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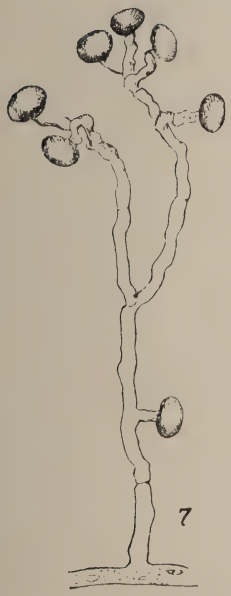
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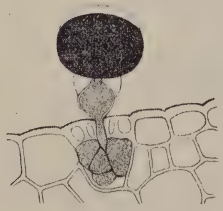
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EXPLANATION OF PLATE XV.

Fig. 1. *Basisporium gallarum* Moll. After Molliard.
Fig. 2. *Basisporium gallarum* Dale nec Moll. Orig.
Fig. 3. *Nigrospora* sp. isolated from banana. Orig.
Fig. 4. *Acremoniella occulta* Ashby (1913). After Ashby
Fig. 5. *Coniosporium Gečevi* Bubák. After Bubák.
Fig. 6. *Epicoccum hyalopes* Miyake. After Miyake.
Fig. 7. *Acremoniella occulta* Cavara. After Cavara.
Fig. 8. *Nigrospora Panici* Zimmer. After Zimmermann.
Fig. 9. *Glenospora elasticae* Koorders. After Koorders.

All magnifications approx. × 375; all reproductions have been calculated from the author's diagnosis; this has led to altering three published magnifications.

Species	Published magnifications	Corrected to agree with diagnosis
Basisporium gallarum	approx. × 1000	approx. × 720
Nigrospora Panici	× 450	at least × 660
Epicoccum hyalopes	× 600	approx. × 270

ALEURIA REPANDA PERS.

(With 4 Text-figs.)

By Jessie S. Bayliss Elliott, D.Sc. (Birm.), B.Sc. (Lond.).

(1) Response of the Apothecia to Light.

In June 1926 some hundreds of fruit-bodies of *Aleuria repanda* Pers. came up in my garden tool-shed. The light arrangements in the shed and the uneven surface of the substratum on which the fungi were growing afforded an excellent opportunity for

Fig. 1. Photograph showing the reaction of the apothecia to light. The light entered the dark shed from the right-hand side. The discs are at right angles to the incident light, while the stalks are parallel with it.

observing that the fruit-bodies are sensitive to light and capable of carrying out heliotropic curvatures. During the time the apothecia were forming, the window of the shed had been covered with planks, and thus the shed had been converted into a large dark chamber which received light only through the door, where it entered through a small hole and a chink at the base. The fungus grew on an old jute hearth rug, used occasionally for protecting a garden frame; while wet it had been folded into a rectangular form and placed in a corner of the shed opposite the door; instead of lying flat, a portion was reared vertically in a plane parallel with the door at right angles to the

incident light and the rest formed a shallow trough, whose vertical sides were at right angles to the door and parallel with the incident light.

When quite young the apothecia resembled tiny goblets with a short stalk; when about one-third grown the short stalks were still visible but the cup-like portion became flattened and revolute at the margin. The diameter of the discs at this stage was about 3 cm. It was evident that the apothecia were

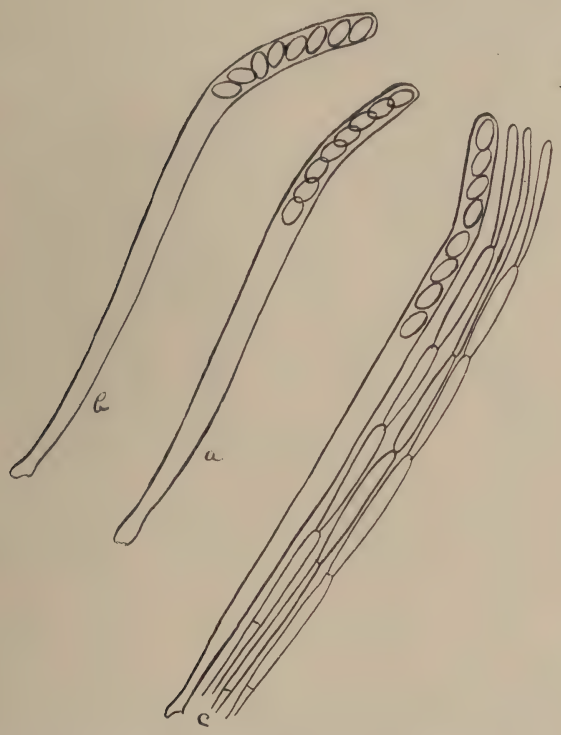

Fig. 2. Heliotropic curvatures of asci and paraphyses. × 550.

adjusted to the direction of the incident light because all the discs were arranged in vertical planes parallel with the door, that is, at right angles to the incident light (Fig. 1).

To bring about this adjustment, all the stalks of the apothecia growing on the back vertical portion of the rug stood out from it at right angles, while the stalks of those growing on the vertical sides of the trough-like portion curved round at the base and assumed a horizontal position in planes parallel with the vertical sides (Fig. 1). By this heliotropic response of the

very short stalk, the hymenial surfaces of the apothecia were placed at right angles to the incident light. Apart from this response, which might be considered a kind of coarse adjustment of the fruit-body, the asci and paraphyses also responded to the stimulus of light (Fig. 2 *a*, *b*, *c* and Fig. 3). Asci are first

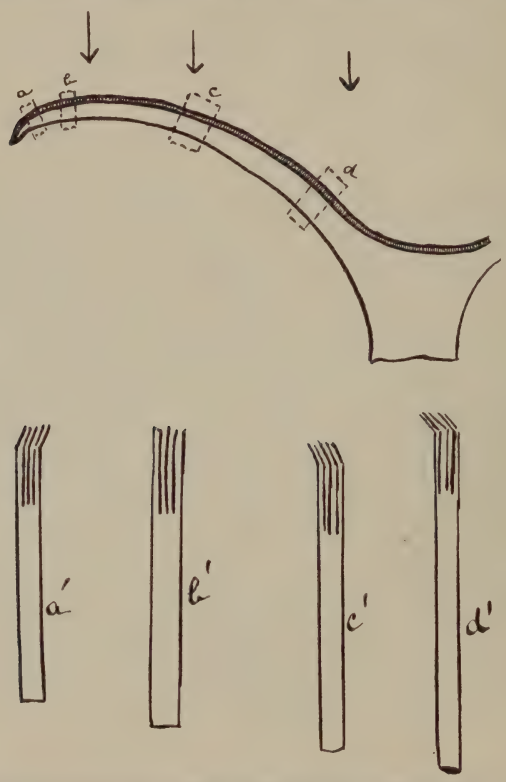

Fig. 3. Diagrammatic figures (vertical section) illustrating the curvatures of asci in a moderately young apothecium when subjected to unilateral illumination. Arrows show the direction of the light. Portions are taken from positions (*a*, *b*, *c*, *d*) and much enlarged at (*a'*, *b'*, *c'*, *d'*) so that the curvatures of the terminal portions of the asci may be seen. The shaded portion is the hymenium, consisting of asci and paraphyses.

formed at right angles to the hymenial surface and normally are thus parallel with the incident light. But here the apothecia were receiving only unilateral illumination, so that in the very young cup-like stages and on the revolute margin of older ones, the terminal portion of each ascus, containing the ascospores, curved so as to become parallel with the incident light (Fig. 2 *b* and Fig. 3): sometimes the portion of the ascus which curved

was quite short, only two or three ascospores being included (Fig. 2 *a* and *c*.)

Many of the fruit-bodies attained a large size (diameter 8 to 10 cm.) and then the hymenial surface became very uneven and the margins very revolute, so that the discs, which when young were flattened and had their whole surfaces at right angles to the incident light, now, because of unequal growth or pressure of neighbouring fruit-bodies and substratum, could not retain the original position, and it was chiefly by heliotropic curvatures of the asci (Fig. 2 *a*, *b*, *c*) that suitable adjustment to the light was attained.

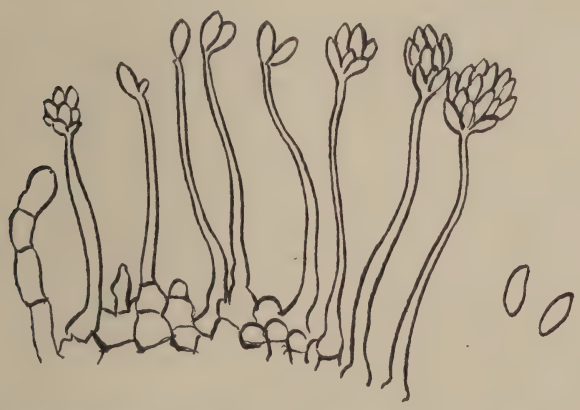

Fig. 4. *Aleuria repanda*. Condiophores with clusters of conidia. Note the conidiophores are extended cells of the excipulum. × 900.

(2) A Conidial Stage.

While examining the fruit-bodies of *Aleuria repanda* I found a conidial stage of the fungus. The exterior of the fruit-bodies is usually very granular, but many of the very young apothecia and those about two-thirds grown looked particularly mealy. This was due to conidiophores bearing clusters of conidia which in general appearance under low magnification suggested a minute white *Aspergillus*. The conidiophores were aseptate and unbranched and arose as tapering filamentous extensions of some of the cells of the pseudo-parenchymatous excipulum. Each conidiophore bore a head of conidia, which were loosely attached by minute sterigmata. The conidia, which were colourless, aseptate, oval, and measured $12\mu \times 4\mu$, were produced in such profusion that, although some were pushed off their sterigmata by the

growth of neighbouring ones, they adhered in clusters of ten to twenty or more.

Brefeld[1] describes a conidial stage of *A. repanda* which he obtained in cultures from ascospores. The conidia agree in size and shape with those described above, but the conidiophores were branched and conidia were produced in clusters on inflated ends quite unlike the simple tapering conidiophores which developed on my specimens.

A NOTE ON THE "BUD-ROT" OF APPLE TREES.

By W. A. R. Dillon-Weston, M.A.

In recent years apple trees have been attacked by a disease of the flower buds which causes the unopened bud to rot upon the trees, a disease known by fruit growers as "Bud-rot."

The chief symptom to be observed in the orchard is the failure of the bud to open, but later in the season a weft of salmon-pink mycelium may generally be found between the bud scales, and microscopic examination shows mycelium and conidia of a species of *Fusarium*: bacteria also may be present. The conidia are curved and pointed but their size and septation are variable.

The literature of this disease is of recent origin. According to Kidd and Beaumont (1) Bud-rot was first recorded by Wiltshire (2) in 1914 but this would appear to be incorrect, for a note by Salmon and Wormald on "A New Disease of Apple Buds" (3) was published in 1912. The spore measurements there recorded were $25–35\,\mu \times 3{\cdot}5–4{\cdot}5\,\mu$, and the conidia were curved, pointed and usually 3-septate.

Spores which I examined taken from diseased buds in May 1925 were pointed, cylindrical 3–6-septate and varied from $24–40\,\mu \times 3{\cdot}5–4\,\mu$.

Kidd and Beaumont in describing *F. fructigenum* occurring on apples in storage suggested that the fungus was identical with that causing Bud-rot. They describe *F. fructigenum* as being a vigorous parasite, with conidia $30–45\,\mu \times 3–4\,\mu$, and 3- to 7- usually 5-septate.

[1] Brefeld, Mycol. Unters. IX, Table III B, Figs. 32–41; X, p. 336.

Aderhold (4) attributed the disease to *Fusarium gemmiperda* n.sp., and it is interesting to note that the Dutch have stated that *F. gemmiperda* is associated with a disease of pear buds in Holland.

The question then arose whether *F. fructigenum* or *F. gemmiperda* was to be considered as the causal organism, and seeing that Wollenweber did not deal with *F. gemmiperda* in his *Fusaria Autographice Delineata*, I sent him a culture of the fungus causing Bud-rot and some fresh material for his opinion.

The following is an extract from his reply:

"...the pure culture of the fungus sent for comparison appears to me to contain *Fusarium fructigenum* (Fries). I obtained typical sporodochia after inoculating your fungus on lupin stalks. On this substratum, as well as on oatmeal Agar, they were on the average somewhat larger and more septate than you state in your letter, namely 90 % 5-septate and 40–60 $\mu \times$ 3–3·5 μ. There was a lack of typical blue-black sclerotial stroma which is characteristic of *Fusarium*. I therefore isolated the fungus from the natural material sent by you and obtained therefrom apparently the same fungus differing however by numerous sclerotia which appear to be lost again by the further transference of ripe conidia ('die sich bei weiterer Übertragung reifer Konidien wieder zu verlieren scheinen'). The conidia of this second culture correspond with *F. fructigenum* (Fr.) in size and septation. The already mentioned small differences in the behaviour of the pure cultures in the various isolations and parent samples are morphologically of no great importance, although they, as shown by the work of Brown and Horne, show a certain constant uniformity ("eine gewisse Konstanz zeigen"). One could therefore identify the fungus just as well with *F. Blackmanii*, if this kind is uniform. On the other hand there is no reason to renounce the name *F. fructigenum* given by Fries. I have so far found the fungus on *Pyrus*, also on *Cydonia* and *Rosa* fruits and on leaves and branches of *Taxus* and branches of *Sambucus*. It is also identical with the *F. cydoniarum* Roum. which Fautrey collected from rotting quince fruits in 1889 and described the conidia as being 5-septate 40–45 $\mu \times 4\mu$. Further it is probably identical with *F. gemmiperda* Aderhold, almost certainly, although I did not make a full examination of Aderhold's fungus I had the impression it was the same as *F. fructigenum*...."

In the Isle of Ely Emneth Early is the variety of apple tree most susceptible to this disease and during the spring of 1925, 30–50 per cent. of the buds were sometimes affected. Lord Grosvenor also is attacked very severely, Grenadier less severely, Lane's Prince Albert and Lord Derby moderately, and Bramley's

Seedling, Newton Wonder and Worcester Pearmain slightly. The climatic conditions that favour the intensity of this disease appear to be a wet summer and autumn, because following the wet summer and autumn of 1919 and 1924 there were severe attacks of Bud-rot in the spring of 1920 and 1925. The dry summer of 1921, however, considerably checked the disease.

I wish to thank Dr Wollenweber for his most careful diagnosis, Mr Wiltshire for supplying certain references to the disease, Dr H. E. Woodman, and Mr J. C. Ward.

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STUDIES ON PODOSPHAERA LEUCOTRICHA (ELL. & EV.) SALM.

I. THE MODE OF PERENNATION.

(With Plates XVI, XVII and 1 Text-figure.)

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Introduction.

Apple mildew, *Podosphaera leucotricha*, has been an orchard pest for many years but of late, owing to its greater intensity of attack, which has perhaps been made more apparent by the recent impetus given to the apple growing industry, it has become, in England, a factor of great economic importance. In consequence a reinvestigation of parts of its life-history relating to its continual reoccurrence, and more detailed observations upon the method of parasitism of this extremely widespread disease were undertaken. The fungus has been repeatedly studied, especially on the Continent and in America. Seasonal epidemics occur regularly and do considerable damage in spite of the adoption of repressive or exterminative measures. It was hoped that a detailed investigation of certain problems connected with the disease might lead to a more intelligent application of controls and throw light upon the reasons for the failure of combative measures.

The means by which the fungus perennates has not received in this country the attention which it has deserved. To establish irrefutably the mode of perennation under English conditions was one of the principal objects of these investigations. The greater part of the work has been carried out at the Botany School, Cambridge, and the remainder at the School of Rural Economy, Oxford. The research was suggested by Mr F. T. Brooks for whose unfailing help and inspiration the writer is greatly indebted.

Apparently the first reference to perennation of the mycelium of apple mildew was made in Germany in 1889 when Sorauer (37) reported the perennation of mycelium of *Sphaerotheca Castagnei* Lév. on young apple shoots; no other specific information, however, was given. In the same year Galloway (12), in America, reported perennation of apple mildew in mycelial form. Perennation of the fungus through the agency of buds was first reported by Tubeuf (38) in 1910, but no proof was given for the assumption that mycelium existed in the closed bud. In 1921

a record of hibernation of apple mildew by means of the bud was made by Van Poeteren* (25) in Holland, who investigated the mildew on oak and found that its method of perennation was similar to that of the mildew on apple. In both fungi the existence of an overwintering mycelium between the bud scales was assumed. The infestation of buds was indicated by the presence of mildew conidia on young leaves which developed from these buds in spring. He found it hard to believe that all buds on the twig would not be attacked indiscriminately if the disease spread from an outside source, and was led to conclude that mycelium was the probable hibernating body because conidia, according to Neger, do not survive the winter. Observations in America by Ballard and Volck (1) suggested similar means of perennation. In 1918 Fisher (9), in describing an attacked twig, wrote, "Buds formed are infected by the overwintering mycelium and in the spring the fungus resumes activity when the leaves unfold." Höstermann (15) presented strong circumstantial evidence of mildew perennation in buds in 1922. He gathered apple twigs in the winter, brought them into a greenhouse, and sprayed them with various fungicides but found that the buds, on opening, were infected with mildew. This investigator suggested mycelium in the buds as the overwintering agent. In support of the view that *P. leucotricha* might tide over the winter in dormant buds Foëx (11) in 1923 cited Chabrolin's observations on two young apple trees. It was noted that on the opening of the buds the disease spread from the base of the petiole towards the apex of the leaf blade; this, he observed, would suggest that the fungus had overwintered in a still unknown form under the leaf scales in the buds.

It may be said that the records of past investigations have revealed only a superficial knowledge of the perennation of this fungus.

Perennation by Bud Infestation.

The Time and Method of Bud Infection.

Axillary buds of the apple become infected a full season before opening. Entry is effected at an early stage in bud development. Soon after the new shoot is put forth in spring and leaves are developed thereon, rudimentary buds are produced in their axils which, at the time of infection, are often hidden by the leaf stalks (Pl. XVI, fig. 1), which must be detached to allow inspection. Covered with many hairs, the undeveloped buds present a fluffy appearance and are much flattened, due to the

* I wish here to express my thanks to Dr Van Poeteren for a copy of this paper and to J. L. Steenkamp, Oxford, for his help in translation.

confined growing space. Two bud scales may be seen to be wrapped rather insecurely around the bud, enveloping the base but leaving the apex loosely clasped. The scales, which are easily removed, are found to overlap considerably at the foot of the bud but often leave a gap at the tip, thus providing a point of access for the mildew.

The hyphae responsible for invasion are derived from mycelium established on the young shoot. The tender tissue of the shoot provides a nutritious substratum for the fungus which confines itself mostly to vegetative growth, and soon enmeshes its host with a tangled mass of hyphae. It is not long before the axillary buds are reached and in the absence of adequate protection by the scales at this stage of development, the hyphae enter and become established between the tissues within.

Besides axillary buds, fruit buds on the terminals of spurs are infected. At an early stage the infecting mycelium, derived from the infected fruit bud immediately preceding and adjoining the rudimentary bud, becomes established and is able to invade the tissues within the immature bud because of the inadequate protection afforded by its undeveloped bud scales; here the mycelium perennates until the bursting of the bud. Occasionally secondary infection occurs, *i.e.* an infection of a healthy spur or shoot is brought about by conidia from neighbouring sources. In all bud infections the perennating mycelium becomes established within the tissues early in the season; later penetration is prevented by bud scales.

The Distribution of Hyphae within the Bud.

On teasing apart the enveloping scales a mycelial plate composed of numerous interlacing hyphae may be seen on their inner surfaces. The mycelium is more abundant on the apices of the inner scales where the tissue is not so cuticularised and may be traced between the enclosed softer rudimentary tissues. Transverse median sections through such buds reveal mycelia between all the composing elements. Pl. XVII, fig. 1, shows a median section* through an axillary bud on one-year wood of Cox's Orange Pippin and illustrates the relative distribution of the mildew mycelium. Mycelium is also abundant between the bud scales, but on the approach of winter that nearer the exterior of the bud loses its vitality, whereas the mycelium between the inner tissues retains a healthy appearance throughout the winter. The tissues in the young bud are not so tightly

* The section illustrated was cut through a bud gathered on January 3rd. All the cuticularised bud scales were removed before fixing the material in order to facilitate thorough and rapid penetration.

compacted that they preclude meandering hyphae and, being tender and somewhat sappy, provide adequate organic material to sustain the fungus. As the season advances the buds swell and, becoming ensheathed by additional bud scales, are soon completely enclosed. By this time the mildew has completed its seasonal growth and, with the bud, remains dormant throughout the ensuing months until spring.

Monthly examinations of dormant buds and a series of transverse sections have shown the distribution of the fungus within them throughout the winter. The state of the nuclei, and the normal, healthy appearance of the hyphae show that the fungus is maintained in a living condition (Text-fig. 1). As mycelium becomes established within the buds in spring, soon after the trees are in full leaf, and is stimulated into growth again at a little earlier period, *i.e.* at bud-break the following season, the period of perennation is roughly eleven months.

The presence of haustoria in the leaf tissues enclosed by the bud scales from the time of initial hyphal invasion until the reawakening of the fungus to activity in the spring, presents a means for the immediate identification of the mycelium and provides a method by which the fungus may perhaps be maintained in a living condition. That haustoria play a vital part in perennation seems very probable. No thickening of the hyphae of *P. leucotricha* in infected buds has been observed nor anything which suggested the occurrence of chlamydospore-like bodies as recorded by Ferraris (8) and Petri (24) in *Microsphaera quercina* and by Foëx (11) in *Uncinula necator*, and other Erysiphaceae. It is improbable that hyphae of an obligate parasite, after remaining dormant over long periods, could reawaken into vigorous growth in the absence of some such type of organ or without some means whereby direct stimulation might be received from the host. Mycelium between the outer scales of an infected bud perishes, as also does that on the toughened outer tissues of an infected shoot and it can hardly be doubted that here the haustoria have been put out of action by the hardening of the tissues. Frequent attempts were made to stimulate into growth mycelium on twigs infected the previous season. Inoculation trials on young leaves, using such mycelium, were unsuccessful. An infected twig brought into the laboratory in September was allowed to stand in water for ten days at a temperature of 60–65° F., after which it was kept in a moist atmosphere under a bell jar. A few conidiophores were produced from the mycelial matting. At this time the outer tissues of the twig had not completely hardened off. It is doubtful if death of the exposed mycelium is due to low winter temperatures. Westerdijk (41) has observed that mycelium which is found during winter on peach twigs

does not develop in spring, but Salmon (29), on the other hand, found that conidiophores were produced from patches of mycelium of *Oidium Euonymi japonici* when leaves of *Euonymus* were placed in a damp Petri dish in April and May and again in December. Where, however, the host does not harden, the haustoria probably retain their function and only await stimulation from the host to regain activity. This assuredly seems

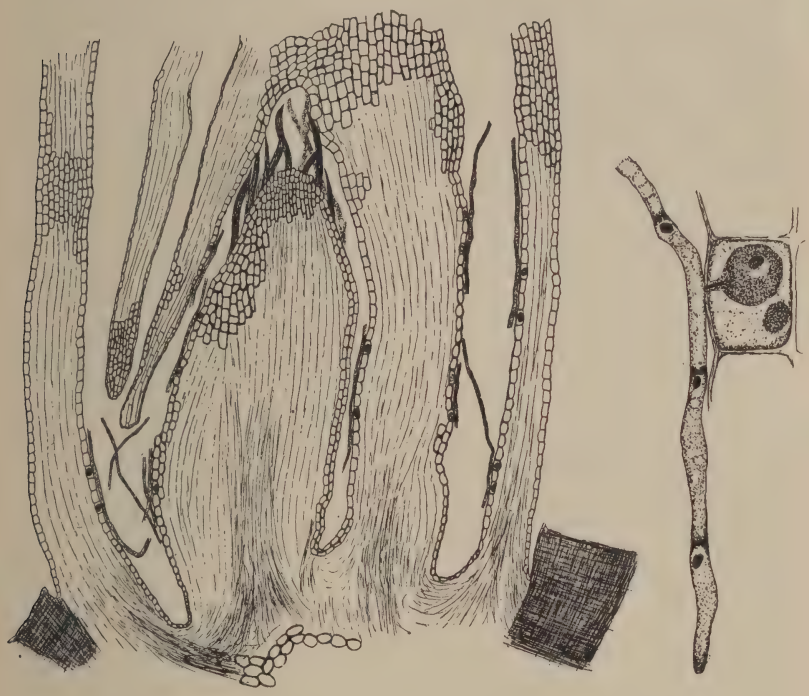

Fig. 1. Diagrammatic drawing of portion of median section through infected axillary bud of Cox's Orange Pippin gathered in January showing normal hyphae and haustoria × 40: on the right a portion of the fungus × 500.

so with haustoria in the tissues of dormant apple buds infected with *P. leucotricha*.

Text-fig. 1 illustrates mycelium and haustoria in an axillary bud of Cox's Orange Pippin taken from one year old "wood" on January 3rd, 1925. The haustoria to which the hyphae are attached appear normal and apparently retain their function through the winter. It will be apparent that with host and parasite in such close and intimate association the parasite will be stimulated into growth as soon as sap is supplied to the

tissues in spring when the buds swell. This is borne out by the actual formation of conidiophores in closed buds.

The Formation of Conidiophores within Closed Buds.

A number of twigs of Fearn's Pippin were gathered on March 7th, 1924, in order to investigate the distribution of hyphae within the buds, and allowed to stand in water in the warmth of the laboratory for four weeks until the buds began to swell: these were excised for examination when a green tip began to protrude between the scales. The tissues of the bud were then teased apart gradually. An axillary bud on "one-year-wood" near the tip of the twig showed no fructifying mycelium on the two outer layers of scales but conidiophores bearing apparently normal conidia were present on the rudimentary leaf tissues. The fungus was fructifying freely on the young leaf-stalks and was producing conidia on them throughout their length to the point of attachment at the base. Chains of conidia occurred on quite tightly folded rudimentary leaves, in the centre of the closed bud; the young leaf-stalk seemed most favourable for their production.

Subsequent observations on buds under outside conditions have often revealed the same phenomenon. Dispersal of conidia may take place at any time during the bursting of the buds; all that is awaited before liberation is the separation of the immature leaves and the unfolding of the buds.

In severe twig infection the buds not killed are often so thoroughly permeated by the fungus that they are much weakened. The portions which suffer most are usually near the tip; the uppermost fringes of the rudimentary leaves turn brown and die (Pl. XVII, fig. 1). Axillary buds on "one-year-wood" are so incapacitated that their growth is checked and the date of opening is delayed compared with their mildew-free neighbours, and this provides a ready means by which infected buds may be detected. It is near the region of killed tissue at the apex of the closed bud that hyphae are as a rule more plentiful, evidently because the mycelium entered the bud first at this point.

In those portions of the infected tissue which have not become definitely brown the epidermal cells invaded by haustoria contain a substance which forms a dark-coloured inner lining to the cell. Definite barriers are thus formed which cut off the haustoria from organic food material; at a later stage, when the tissue has become definitely brown, the haustoria succumb; the epidermal cells shrink and become filled with dark-coloured oily or gummy globules.

On the Distribution on Affected Trees of Buds containing Perennating Mycelium.

The distribution of infected buds on the tree may more easily be studied at two periods; in the autumn when the leaves have fallen and in the spring when the mildewed buds are opening. In autumn their distribution is evident by the whitened appearance of the twigs which have been attacked and, where perithecia occur, by black masses of these bodies on the current season's growth.

It is in spring when the buds burst that the distribution of mildew may be most easily observed by a slightly distorted or stunted appearance of the opening bud and the appearance of conidia on the green leaf tissue protruding from the enveloping scales. Furthermore, the cutting at any time of sections through suspected buds provides a certain method of discovering infection. By utilising these methods the distribution of buds containing viable mycelium or haustoria has been studied. The most frequently infected are axillary and terminal buds on "one-year-wood." When infection is severe terminal buds are killed by the fungus with the consequent death of the mycelium. Indeed, many of the axillary buds on the affected portion of the twig also perish. When infected parts are killed outright, the fungus defeats its own end by depriving itself of living host tissue essential to its existence. Occasionally, when branches are killed back, dormant buds are stimulated into growth on "two-year-wood" and in them the hibernating mycelium which entered when the buds were formed is stimulated into growth. Here the mycelium and haustoria must have remained dormant in the buds for two seasons.

Next in importance to terminal and axillary buds in harbouring the disease are blossom buds on the terminals of fruit-spurs. Such buds may usually be detected in autumn and winter lower down on the same branch as that which bears infected "one-year-wood." The peculiar enamelling effect produced by mycelium on spurs near the base of such buds is sometimes quite marked.

To determine the approximate percentage of mildewed twigs which eventually produced mildewed buds, twigs marked the previous autumn as being attacked by the fungus were gathered in late winter and were allowed to stand in water in the warmth of the greenhouse. Care was taken to remove all perithecia. Infection by wind-borne spores could be safely ruled out because buds produced in the open were dormant at the time of these observations. One hundred and fifty twigs of Fearn's Pippin and fifty of Allington Pippin were kept under observation.

Only forty to fifty per cent. of the twigs visibly attacked by mildew bore buds which opened in an infected condition. Of these buds the terminal, whether blossom or leaf bud, was as important as axillary buds in perpetuating the disease. When the disease first made its appearance it was usually limited to one bud per shoot, more rarely to two or more buds. These observations apply to standard trees of twelve and fifteen years of age but observations on other varieties of various ages indicate in general a similar distribution.

The Association of Mildew with the Development of Shoots from Mildew-infested Buds.

Young shoots of apple become infected at a very early stage in their development, as they arise from infected wood buds or blossom buds. Blossom buds of the apple contain leaves and an embryo shoot in addition to flowers, and differ from peach and plum in being thus provided with a means for further growth at this point. This peculiarity of growth particularly favours the perpetuity of the fungal parasite. On the bursting of the blossom bud the perennating mycelium fructifies freely and attacks its host during all stages of growth (Pl. XVI, figs. 2, 3 and 4). The blossoms are often entirely destroyed and the foliage stunted and contorted. The embryo shoot is soon produced and, as it is in close contact with infection, falls a direct prey to the mildew, and the axillary buds are then invaded.

Perennation by Perithecia.

Notes were kept on material bearing perithecia at: University Farm, Cambridge, twelve trees Lane's Prince Albert; Meldreth, Cambs., twelve trees Fearn's Pippin and twelve trees Allington Pippin; Evesham, about 150 trees of the varieties Early Victoria, Beauty of Bath, Lord Derby and Cox's Orange Pippin. Twigs which bore perithecia were marked early in the autumn and were brought in, a few at a time, continuously until June 8th (for the season 1923–1924). During the season 1924–1925 observations were confined to trees at Cambridge and Evesham until the first outbreak of the disease in spring. During the season 1925–1926 observations were concentrated at Cambridge throughout the same winter period.

The Date of Formation, Incidence, and Time of Duration on the Host.

Perithecia of *P. leucotricha* are by no means scarce, especially on certain varieties of apples. Mature perithecia may be observed as early as May and the appendages of many of the earliest fructifications are fully developed by June. The period

in which perithecia are produced extends well into the summer; freshly formed fructifications may be observed in July and August and may easily be distinguished at this time from the more mature, darker perithecia by the lightness of their colour. On strong-growing twigs, perithecia usually persist throughout the winter months. When a twig is killed, perithecia rarely remain on the host because the mycelial matting peels off, and in doing so they are carried with it. Peeling of mycelial matting often occurs to a limited extent on the central area and towards the extremities of strong-growing, infected shoots; a considerable number of fructifications, however, are almost invariably retained at the base of the area of infection.

Perithecia are produced on: (1) Current season's growth and, on rare occasions, farther down on the same shoot on "two-year-wood" immediately below the junction of the two seasons' growth. When produced on the current year's "wood," which is the normal position, they are usually more dense on the lower part. (2) "Sucker" growth arising from older branches on the lower part of the tree. Not infrequently a shoot thus infected is blackened by dense masses of perithecia. "Sucker" shoots are normally much longer than the infected terminals and are often covered throughout their length by the fructifications which, when congregated into patches, give the shoot a mottled effect. (3) The leaf-stalk, midrib and the larger veins of infected leaves.

Perithecia are said to have been observed on the fruits themselves, but I have not seen any.

External Morphology and Position on the Substratum.

Soon after formation the perithecia are globose in shape, and retain their conformity throughout the greater part of the summer. During September fully seventy-five per cent. of perithecia examined were markedly depressed in their upper surface (Pl. XVII, fig. 2). A very small percentage of perithecia were found without depressions but these were usually smaller in size and suggested an immature condition through later development. The apical appendages arise, as a rule, from the depressed portion of the perithecium. Occasionally the depression occurs on the side of the perithecium and may be observed in the same plane as the basal and apical appendages.

To investigate these concavities, perithecia were subjected in October to a saturated atmosphere under a bell-jar for ten days. No change in the position of the perithecia could be observed; the concavities were as numerous as they were previously. In other trials perithecia were subjected to a saturated

atmosphere in a Van Tieghem cell and in a Petri dish on their original substratum, but their shrunken condition was unaltered and their respective positions unchanged. Similar trials were continued in November but without success. In February further experiments yielded negative results, although at this time tap water was frequently sprayed upon the perithecia by means of an "atomiser."

It was thought that the depressions mentioned might have something to do with detachment from the substratum. Neger (19) found the wall of the perithecium of *Erysiphe graminis* and more markedly that of *E. taurica* composed towards the exterior of several layers of very strongly thickened cells. He found the layers of thick-walled cells more numerous on the upper side; on loss of turgescence, the perithecia became slightly concave on the upper surface. *Microsphaera* showed the reverse condition, *i.e.* on the lower half were thin-walled, flexible cells which became depressed and formed a concavity on the lower surface; *Podosphaera* showed similar structure. In classifying the genera according to the detachment mechanism of the perithecia, Neger placed *Podosphaera* in the group in which perithecia fall off when ripe, the detachment being caused by the shrinking of the perithecium base due to the presence there of more delicate cellular formation. I am unable to agree with Neger in regard to the position of the depression for, as already pointed out, the perithecia of *P. leucotricha* are concave in the upper half. Further, because of the position of the depression, it is difficult to imagine that it can have anything to do with detachment as it is obvious that the filling out of the upper half of the perithecium would not bring into play any displacing mechanism. Moreover, the writer found that the perithecia of *P. leucotricha* were normally retained by their host both on twigs brought into the laboratory and on trees in the plantation. In this connection special note was kept on thirty-five twigs of Lane's Prince Albert bearing perithecia, in order to learn whether the latter were naturally shed at any time. When observations were begun in August perithecia were plentiful; by October their number appeared to have increased. This augmentation was probably due to the ripening of some of the less mature fructifications. By November perithecia were abundant on seventy-five per cent. of the twigs under observation; on the remainder their number had decreased and, in a few cases, were absent. After this date they remained constant throughout the winter. In the few twigs noted in which the perithecia were shed, peeling of the mycelial matting from the host was observed. Further observations were kept on thirty-six twigs of the variety Mr Gladstone at Evesham upon which

perithecia were observed in September. By January 31st only three were without perithecia; the remainder had a plentiful supply which were still present at the end of February.

The perithecium is attached to the substratum by the basal appendages which are short and tortuous. The apical appendages are long, slender, stiff and taper characteristically to rather a blunt point. Salmon has described the apices of the appendages as "rarely once or twice dichotomously divided." During observations carried on for three years on numerous perithecia in all stages of development I have seen only two examples of this and have been unable to find septa in young or old appendages as recorded by this author, and more recently reported by Cunningham (7) in New Zealand. The number of apical appendages varies greatly; often they are absent, due to falling off or non-development. As many as ten may be counted sometimes and when a great number of perithecia is aggregated in dense masses the erect appendages give these dark blotch-like congregations a very characteristic, bristly appearance, which suggests a capacity for collection and retention of the moisture essential for germination purposes. The original specific use of these organs or their present use is a matter for conjecture, but it is difficult to imagine that they could play a part in the detachment of the perithecium as do those of *Phyllactinia*, although it has been noted that when globose perithecia are placed in water and swell slightly before rupturing the apical appendages spread themselves in a fan-like manner.

The Method of Dehiscence of the Ascus and Ejection of Ascospores.

The perithecium is a true cleistocarp, the ascus being ejected through an irregular rupture of the wall. The split usually occurs at a slightly oblique angle to the base separating, at times, the apical appendages situated in the equatorial region from those nearer the apex. The opening formed gradually widens owing to the expansion of the ascus following the absorption of water. Harper (14) has suggested that the cells of the inner wall of the perithecium of *Sphaerotheca Castagnei* permanently retain their nuclei and may produce a substance capable of swelling in water which would cause the rupture of the wall. Because of the absorptive capacity of the ascus and the great force it would be capable of exerting on the perithecial case, Harper's assumption seems unnecessary to explain this phenomenon in *P. leucotricha*. The perithecial wall is elastic and responds to the pressure exerted from within until the opening, although of smaller diameter, can no longer restrain

the ascus which squeezes through the orifice and is violently ejected. The force of ejection is considerably increased by the snapping together of the "jaws" of the orifice due to the elasticity of the perithecial case. Occasionally the ascus is not emitted but ruptures within the perithecium and the ascospores are then liberated through the orifice in the perithecial wall. As a rule, however, the ascus is ejected intact with subsequent rupture of the ascus sac and liberation of ascospores; when this occurs the ascus is often thrown several cm. in the air. On reaching water, or in a damp atmosphere, it continues to swell and within one or two minutes explodes, scattering the ascospores in all directions. The wall of the ascus of *P. leucotricha* is of the same thickness throughout and no "pore" has been observed near the apex as Salmon has described in *Sphaerotheca Humuli* (30) and *S. mors-uvae* (31). The split occurs in the apical region and the opening is quite conspicuous in a shrunken ascus which has been emptied of its contents.

A Van Tieghem cell was used for the examination of ascus dehiscence. The material under observation was placed on wet blotting paper and was enclosed by a glass ring so as to support over the material a small drop of water on the under surface of a coverslip which was used to catch the ejected spores. Both ascus sacs and ascospores were shot on to the coverslip. In other trials in which perithecia were placed in a hanging-drop the gradual splitting of the perithecial wall and emission of the ascus could be minutely observed. Ejection of the ascus on to the coverslip occurred only in one lot of material from Lane's Prince Albert. Ejection of asci took place during the week February 7th to 14th, 1924, on material from two only of all twigs under examination. On placing mature perithecia in a hanging-drop ascus emission took place after three minutes' immersion and two minutes later the ejected ascus liberated its ascospores. In subsequent trials the perithecial wall ruptured after five minutes' immersion but no asci were emitted until six hours later. By this time a number of other perithecia had ruptured but nearly all retained their asci and ascospores. Other perithecia ejected their asci after three hours' immersion while others, in the same hanging-drop, only showed a preliminary split by this time. It seemed evident from these trials that maturity of the perithecium is a factor controlling rapidity of dehiscence. A great number of trials, continued through February and March until the disease was evident on the opening buds, yielded only one additional instance of ascus emission; the ascus sac, however, did not liberate its ascospores.

During these experiments no ready means for detecting a viable perithecium was discovered. For instance, in an ex-

amination of seventy perithecia of which the greater part appeared globose and of a healthy, dark brown colour, only three contracted a preliminary rupture, none emitted asci. But the general shrivelled condition of the greater number of these perithecia was forcibly brought to my attention.

The Function of Perithecia and Comparisons with other Erysiphaceae.

On account of the shrivelled condition of the majority of perithecia from September onwards and the apparently non-viable condition of the remainder it is impossible to ascribe to them any function in the life-history of the disease.

Galloway (12) in America first suggested the unimportance of the sexual form of *P. leucotricha*. Some time later Ballard and Volck (1) in California came to the same view. In 1918 infection trials with ascospores were undertaken by Fisher (9) but without success. This investigator assumed that the "ascospores play little, if any, part in spreading the disease and that they are unnecessary to the overwintering of the fungus." To establish the part played by perithecia under English conditions, records were kept by the writer over the seasons 1923–1924, 1924–1925, 1925–1926.

Perithecia in their natural habitat on infected twigs were kept under close observation in various localities, and in the laboratory, from development to maturity and final collapse and disintegration. Ten varieties in representative apple growing districts were kept under observation. All trials emphasised the non-viability of the ascospores and, except for the one instance previously mentioned, the non-ejection of asci.

To learn whether perithecia on leaves which fell in autumn provided a source of infection in spring, the following observations were made. Fifteen leaves gathered from Lane's Prince Albert trees at Cambridge University Farm, with a copious supply of perithecia on the midrib and leaf-stalk were placed, in August, in an exposed position in the open but protected from the wind by netting. By October 20th the leaves with the accompanying ascogenous form of the fungus had disintegrated. None of the perithecia on the leaves survived. Although some might have fallen on the surrounding soil, it appeared very improbable that any retained their viability until spring. No definite conclusions can be drawn but evidence seems against retention of viability by such perithecia.

The examination of perithecia from the various sources named revealed: (*a*) a collapsed condition; (*b*) loss of texture in the perithecial wall; (*c*) undeveloped, abnormal ascospores and (*d*) an extraneous fungus within the perithecium.

The collapsed condition of the perithecia has already been discussed. The fact that perithecia do not regain their normal shape when subjected to a saturated atmosphere indicates loss of vitality. Throughout the winter months and in spring the collapsed perithecia, or those which had retained their original globose shape, crumbled when crushed in water under a cover-slip in a manner which suggested their lifeless condition. Normally, ascospores are fully formed before the end of the summer. By September or a little later, when the upper half of the perithecium becomes depressed, the ascospores are small and the ascus appears shrunken when pressed out, and does not swell on immersion in water. Spores of an extraneous fungus were not infrequently observed in perithecia*. Upon pressing, a stream of non-septate spores was emitted but, when the perithecia were allowed to remain in water, saprophytic hyphae soon grew out from the periphery. Common moulds and Mucors often developed. A parasitic attack by such fungi seems improbable. During the summer months until September these fungi are not in great evidence; it is only after shrivelling that they become increasingly evident. In the light of repeated observations, no other assumption can be entertained than that they are saprophytic organisms. Salmon (28) has observed that sometimes when perithecia of mildews (not apple mildew) are crushed a stream of very small biguttulate spores of *Cicinnobolus Cesatii* de Bary, 6·5 to 10·5 $\mu \times$ 3·5 to 6 μ, immersed in a colourless, mucilaginous substance is emitted. There may be found on the same mycelium smaller bodies oval to pyriform in shape without appendages and containing the same kind of spores. Such pycnidia have been found in association with mildew hyphae in the vicinity of parasitised perithecia of *P. leucotricha* but no pycnospores were observed within them. No signs of the parasite have been observed in the conidial stage of *P. leucotricha*. In order finally to establish the identity of the spores emitted from perithecia of *P. leucotricha* further corroborative observations are necessary.

Comparatively little is known of the part played by perithecia in the Erysiphaceae. Salmon (31) has made observations on *Sphaerotheca mors-uvae* of which he found mature perithecia in August which, he thought, had spread the disease that summer. He found that some perithecia gathered in November emitted ripe spores when moistened in February after remaining dry at 15° C. in the laboratory through the winter. On the other hand, perithecia exposed on the bush through the winter

* Prof. Salmon, to whom the writer is much indebted, has kindly examined microtome sections of perithecia attacked in this way and has suggested parasitism by *Cicinnobolus*.

did not show any mature asci in February. The probability is mentioned that those perithecia which reach maturity early fall to the ground and may be responsible for spring infection. The improbability of this in *P. leucotricha* has already been pointed out. In *Erysiphe graminis* Salmon (32) found that when perithecia were kept dry in a box in winter, ascospore production could be started at any time by moisture. He found that the ascospores germinated in water, with the production of germ tubes from both ends of the spore. Galloway (13), in his observations on *Uncinula spiralis*, found that one of the first changes in the appearance of perithecia in the winter was the gradual disappearance of the appendages. By the end of December he found that many of the asci were dead or collapsed and that germination of ascospores could not be induced until February and then only after many trials and the exercise of great perseverance. A large part of the spores burst as soon as they were free from the asci. In bursting, the spores scattered the walls and contents in all directions. Ascospores of *P. leucotricha* which were of normal size and were naturally ejected occasionally behaved similarly when allowed to remain in water; however, no sudden bursting occurred, but the wall of the ascospore split and the spore contents were emitted in a stream, while the ascus sac gradually collapsed.

Factors influencing the Formation of Perithecia.

Neger (22) has suggested that "La formation des périthèces implique un milieu nourricier âgé (adulte) non encore épuisé par la production de conidies." My observations hardly suggested these conditions; the development of perithecia was observed as early as May on young growth: dryness sometimes favours their production. *Erysiphe taurica* produces perithecia on *Phlomis Herba-venti* when the leaves dry, but *Microsphaera quercina* produces them more often in shaded spots than in the open. Bioletti (3) has observed that warm, moist weather favours luxuriant mycelial growth in *Uncinula necator* and if followed by a sudden lowering of the temperature to about 50° F. the formation of perithecia is speedily induced.

One of the more important conditions which favours the production of perithecia in *P. leucotricha* is severe hyphal infection of the shoot in a young stage. Perithecia are uncommon where the fungus has not previously obtained a firm footing accompanied by a thick coating of mycelium; the early and vigorous infection of certain shoots is often followed by perithecial development. "Sucker" shoots become thoroughly parasitised at an early stage and perithecia are usually copiously produced. Examinations made through the spring and the summer

for the presence of perithecia on the current season's growth revealed the fact that they were present on only a limited number of infected twigs on each tree. Shoots without perithecia had not often suffered a severe hyphal attack. Varietal susceptibility to mildew may in this way be a factor limiting perithecial production. Severely infected varieties such as Lane's Prince Albert bear numerous perithecia, whereas many of the more resistant varieties bear perithecia only sporadically. Occasionally the soil or other environmental factor may break down the resistance of a host and the shoots suffer in consequence an early and severe infection followed by production of perithecia.

II. OBSERVATIONS ON SOME HOST-PARASITE RELATIONSHIPS.

I. The Conditions for Germination of Conidia of *P. leucotricha*

The conditions necessary for germination of conidia of *P. leucotricha* have received little attention by past investigators, but many investigations have been made on other Erysiphaceae. Morgenthaler (18) found that *Oidium Tuckeri* thrived at 5–10° C. and had an optimum temperature for growth at 25–30° C. Rauch (26) found feeble germination in *Sphaerotheca pannosa* at 6–8° C., a good germination at 12° C. with an accelerated growth at 17–30° C. In *Sphaerotheca Humuli* on strawberry, Salmon (30) found feeble germination when conidia were sown in hanging drops at the ordinary temperature; after a preliminary subjection to 0° C. germination was greatly increased. Voglino (39) found that conidia of *Phyllactinia corylea* germinated between 4 and 35° C. but died regularly at 0° C. This author also found that the optimum temperature for the production of conidia on leaves was between 18 and 25° C. Germination in *Erysiphe graminis* according to Rivera (27) was inhibited at 29 and 30° C. and death occurred at a higher temperature. Schaffnit (35) has obtained germination of the conidia of this fungus after subjection for six to eight hours to a temperature of −17° C. There is thus a wide range in the temperature requirements of mildews.

During observations on conidia of *P. leucotricha* during 1924 and 1925 unknown factors which inhibited germination were encountered. On February 23rd, 1924, conidia gathered from breaking buds of Fearn's Pippin "forced" in the laboratory were set up in a hanging drop preparation but did not germinate. Again, on April 4th, conidia from Cox's Orange Pippin similarly produced were sown in water in a watch glass but no germination took place.

Subsequent trials in watch glasses and hanging drops, on April 12th, also proved unsuccessful. On April 14th, in similar preparations, slight protuberances were noted in certain conidia accompanied by the shrinking of their contents. On April 27th, after 40 hours, a very small percentage germinated on the surface of tap water and on the moist surface of the watch glass containing it. On May 6th a feeble germination was again obtained although a previous trial, on May 2nd, yielded negative results.

In the following year the percentage germination was sampled during the period of conidia production in the plantation. The conidia were sown in drops of water on ordinary microscopic slides which were then placed on damp blotting paper in a moist atmosphere provided by a bell-jar lined with moistened filter paper. From May 2nd to the 7th a series of five separate preparations, in which eleven hundred and forty-two conidia from Fearn's Pippin were kept under observation, yielded an average germination of two to three per cent. In another series of trials from May 9th to the 12th, in which Newton Wonder provided the material, the percentage germination was approximately the same and four other series of trials carried out during May and June yielded similar results. When continued in August and September the germination was very feeble indeed and later, in November, conidia which developed on the tissues of a breaking bud "forced" in the laboratory did not germinate although apparently normal.

These results led me to undertake a further series of trials in the following year, 1926, to investigate the factors limiting germination.

The Effect of the Host Plant on Germination of Conidia.

In a trial on April 24th, 1925, conidia from apple leaves were sown in two watch glasses containing tap water. A mildewed leaf was placed in one of these vessels and both preparations were kept in a damp atmosphere under a bell-jar. After three days a very small percentage had germinated in the preparation containing tap water alone; that to which the mildewed leaf had been added contained no germinating spores, presumably because tannin and products of decomposition had diffused from brown areas on the leaves into the water, and thus produced a medium inhibitory to germination. It was then thought that the sowing of conidia on a healthy leaf might influence germination. Accordingly, conidia were sown on a healthy leaf placed in a moist Petri dish and the necessary control was sown in a moistened watch glass, covered and placed in a damp chamber. The conidia on the leaf germinated and conidiophores

were produced six days later; no germination occurred in the moist control. Sometimes two or even three germ tubes were produced from conidia sown on healthy leaves whereas, in the event of germination occurring in a moistened watch glass or on a slide, never more than one germ tube has been observed. In other trials at temperatures of 0° C., 10° C., and 15° C. poor or no germination was constantly observed in the absence of healthy leaf tissue. Conidia of *P. leucotricha* sown on healthy, young oak leaves, set up in a similar way, germinated successfully, which seemed to indicate that an apple leaf exerts no peculiar influence. As was expected, conidiophores were not formed on oak foliage although an extensive growth of hyphae was evident, whereas in a control on apple leaves conidiophores were produced in the usual time. In another trial the expressed juice of healthy, green apple leaves was used as a germinative medium; no germination occurred therein or in a control of water alone but germ tubes were produced when sown in the normal manner on healthy apple leaves. Neither a watery extract of horse dung nor a two per cent. solution of cane sugar brought about germination. A healthy leaf apparently provides a most favourable substratum for germination although no adequate explanation suggests itself for this: possibly transpiration or the exchange of gases from the leaf might provide suitable conditions for the germination of the conidia of this mildew.

The Effect of Temperature on Germination of Conidia.

It was thought that temperature might directly affect the germination of conidia and thus be a factor controlling the seasonal appearance of the disease, Salmon's results with *Sphaerotheca Humuli* suggesting that the absence of spring frosts might check it somewhat.

Accordingly, preparations were set up in Petri dishes moistened with sufficient water to keep the leaves turgid. The conidia were gathered from fresh material and sown on healthy leaves lightly sprayed with tap water by means of an "atomiser." No germination had occurred after the Petri dish had been buried in ice for fifty-four hours. A leaf was removed after subjection to this temperature for twenty-four hours, and germination took place seven hours later at a temperature of 10° C. A leaf removed from the ice chamber after a fifty-four hour period showed in six hours at a temperature of 10° C. conidia with germ tubes which extended a distance equal to their length. In a control in which conidia were sown on slides kept moistened in a damp chamber, germination did not occur after thirty-one hours either in ice or in the laboratory at 10° C. One of the slides placed in the ice chamber was removed after twenty

hours to the laboratory temperature of 10° C., but no germination occurred.

After subjection to a temperature of 8° C. for twelve hours conidia sown on an apple leaf germinated upon removal from the cold chamber and conidial chains were developed six days later. Control conidia on leaves in the laboratory at 15° C. produced conidiophores at approximately the same time as those subjected to cooling. In other trials normal germination occurred on leaves at a room temperature of 10° C. twenty-four hours after sowing. In an incubator kept at a temperature of 20° C., vigorous germination occurred on leaves after twenty-four hours. The germ tubes were twice as long as those of conidia from an identical source sown at the same time in a temperature of 10° C. Another series of leaf preparations was subjected to temperatures of 15° C., 20° C., and 33° C. Careful examination of conidia on the leaves showed that germination was initiated at 15° C. after six hours and had not begun at 20° C. or 33° C. By the end of a period of twenty-one hours the production of germ tubes at 20° C. was in advance of those at 15° C., but was altogether absent at 33° C. in which the light brown colour which many conidia assumed showed that they had been killed. Moreover, well-defined areas of the leaves had been killed by the sudden change to excessive heat.

Temperatures from 0–10° C. do not tend to stimulate germination but rather to keep the conidia in a dormant condition; 10–15° C. is most favourable, 20° C. favours the growth of germ tubes, and 33° C. causes death of the conidia. These temperature relations apply to artificial conditions obtaining on excised leaves in a Petri dish and, although near to, do not perhaps, truly represent natural conditions for infection and growth of the fungus.

Moisture and Light Relations.

Neger (20) found that light caused acceleration of germ tube development in many of the Erysiphaceae. This factor has little or no influence on the germination of conidia of *P. leucotricha*, germ tubes being produced readily in the darkness of an incubator and at night. Moisture, however, is of some importance; surplus water on the leaf surface is unfavourable. Successful germination was obtained when the leaf to be inoculated was sprayed lightly with an "atomiser" at the time of sowing, comparable to a light fall of dew. Once germination had taken place, although the leaf surface was not further moistened, a vigorous growth of hyphae was induced followed by a copious development of conidiophores. On the other hand, production of mycelium and conidia did not occur on moist

portions of the leaf and germination was impeded by a very wet leaf surface. Moreover, a dry leaf surface favoured the rapid extension of hyphae and encouraged the production of conidial chains, but for this the host tissue had to be turgid and of high water content. Trials undertaken to discover whether conidia sown on a dry leaf would germinate showed normal germination to occur followed eventually by the development of conidiophores.

In nature a dry spell is not inhibitory to germination and to the dissemination of the disease. Although sufficient moisture is always supplied by night dews, even this seems unnecessary. It has been noted that during dry seasons mildew is more epidemic as, for example, during the season of 1921. Probably the season itself only indirectly influences the disease, whose incidence is directly controlled by the vigour of the host plant. Tender tissue of high water content is very susceptible to attack and whenever seasons or cultural practices bring about these conditions the disease is encouraged.

II. The Mechanism of Infection and Means of Dispersal.

The Penetration of the Cuticle and Formation of Haustoria.

Grant Smith (36) has described in some detail the mechanism of haustoria formation in *Erysiphe communis* on *Geranium maculatum*. The description he has given of cuticular penetration agrees closely with that observed by the writer in *P. leucotricha* with the exception that the haustorial sheath is often absent in this mildew. The sheath* as described by Smith precedes the advancing haustorium and, it is said, is composed of the decomposed distal portion of the cellulose protrusion which is formed in advance of the fine, penetrating process of the fungus. The decomposed cellulose which is formed completely round the haustorium is confined by the membrane of the host cell and the membrane eventually forms a U-shaped pocket in the epidermal cell. The cell membrane did not always remain intact, and then the haustoria were unprovided with sheaths, the haustorial membrane being in direct contact with the protoplasm of the host cell.

This description would serve also for *P. leucotricha*. Plate XVII, figs. 3–6, illustrate typical penetration of the epidermal cell. Connection with a parent hypha is difficult to obtain. At the point of contact with the host plant no special organ or thick-

* Harper, R. A., *Pringsh. Jahrb. wiss. Bot.* xxix (1896), 664, has given a different interpretation to this sheath. He considers it to be the disorganising nucleus of the host cell.

ening suggestive of an appressorium has been observed; the hypha is drawn out into a heel-like process (Pl. XVII, fig. 8), but the actual connection between parasite and host arises directly from the hypha and not from any outgrowth or protuberance of the hypha.

There are two hypotheses regarding the means by which penetration of the cuticular barrier is effected, but neither has been evolved from the study of infection processes peculiar to an obligate parasite. The first was postulated by de Bary (2) in 1886, infection of stems of broad beans by *Sclerotinia Libertiana* having led him to conclude that the cuticle was softened by a substance secreted by the fungus and that a toxic substance diffused through the cuticle, causing the death of the cell. Marshall Ward (40), in his study on *Botrytis*, found that parasitical attack on the cuticle was fostered by enzymatic action and that the fungus lived on the gelatinised walls. Yellow spots were caused by the deposition of an enzyme on the host at the tips of invading hyphae; owing to the difficulty in dealing with an obligate parasite such as *P. leucotricha*, any attempt to prove the existence of an enzyme involves great technical obstacles.

The second hypothesis was advanced by Blackman and Welsford (4) and Brown (5 and 6) as a result of their studies on *Botrytis cinerea*.

Blackman and Welsford showed that actual penetration was effected by pressure exerted on the underlying tissues, accompanied by the development of a fine peg-like growth from that part of the germ tube firmly pressed against the leaf surface. Prior to penetration of the cuticle no softening, swelling, or any other change was observed in the cuticle or in the underlying layers of the epidermal wall. Penetration could occur without the development of an appressorium but it was shown that attachment to the host, in penetration by mechanical force, was provided by a mucilaginous sheath investing the germ tube. As soon as the cuticular barrier had been forced, enzyme action could occur, as was made evident by the swelling of the subcuticular layers.

Results of preliminary observations on infection by germ tubes of *P. leucotricha* seemed somewhat similar to those of de Bary and Marshall Ward. When a conidium of *P. leucotricha* is placed on the surface of a leaf and germination occurs, a small area of the surface of the host tissue situated directly under and near to but not at the tip of the germ tube becomes light brown or yellow. This also occurs under other portions of an extended hypha. In these experiments whole, healthy apple leaves were used and the conidia were sown so as to ensure distribution on the midrib and larger veins as these portions particularly lend

themselves, through the absence of chlorophyll, to ready examination with an ordinary microscope. The discoloured area is not confined to one cell but spreads over adjoining cells not underlying the hypha, making it clear, therefore, that this discoloration cannot be due to haustorial penetration, a point which is confirmed by sections. The colour, moreover, is not typical of the browning within the epidermal cell which often follows the development of haustoria. Similar browning of well-defined areas of the leaf surface in contact with germ tubes from conidia of *P. leucotricha* sown on young oak leaves has also been observed: the colour of the affected portion is darker on this host but the area extends in the same way over adjoining cells. The infecting germ tubes were not immersed in water or in an "infection drop" at any time during these observations; they lay on a substratum visibly free from water.

Although hyphae of *P. leucotricha* conform closely to the leaf surface, they are not firmly attached until haustoria have been formed. Microscopical preparations have not shown hyphae adpressed against the cuticle of the host at the point of penetration, or attachment by a mucilaginous sheath. Some means of maintaining contact between hypha and cuticle during penetration must be shown to exist before the theory of penetration by mechanical force can be accepted to explain the penetration of *P. leucotricha*. If penetration is purely mechanical, a relatively great force must be exerted to penetrate the strongly cuticularised cuticle. Without means for maintaining a close contact between host and parasite during the exertion of the force, it is difficult to imagine mechanical penetration. Nordhausen (23) found that heavy dews so weakened the enzymes of the spores of *Botrytis* that penetration was impossible and that for enzymatic action to ensue the leaf surface must be dry. With *P. leucotricha*, whenever the leaf is kept covered by a film of water infection does not occur. When the cuticle is thick, a knob-like swelling of the penetrating organ occurs (Pl. XVII, figs. 7 and 8) somewhat similar to that observed by Grant Smith (*loc. cit.*) in *Erysiphe communis*. This enlargement of the passage through the cuticle occurs near the exterior and might be a pit-like cavity caused by enzymatic action. Also the slight swelling of the cuticle (Pl. XVII, figs. 3 and 4) which accompanies penetration might be due to enzymatic action. After its passage through the cuticle the penetrating hypha becomes thin and peg-like. To what extent either of the two hypotheses of penetration may explain the infection processes of *P. leucotricha* still remains to be demonstrated plainly.

After penetration of the epidermal cell has been effected and the young haustorium formed, the nucleus is introduced, pre-

sumably by way of the extremely narrow canal through the cuticle. Although its passage has not actually been observed, it must, as Smith has pointed out, be a remarkable process, for the tube has a diameter many times less than that of the nucleus. The mature haustorium is usually uninucleate but occasionally binucleate (Pl. XVII, fig. 7). Dark-coloured granules may be distinguished in a suitably stained haustorium nucleus. Although the attacked epidermal cell usually contains one haustorium, two or more have sometimes been observed. When the haustorium is fully mature it often occupies the greater part of the interior of the cell and, except where the invaded cells have turned brown, the host nuclei normally retain their function; the nuclei of the haustoria and of the host coexist in the infected cell without any apparent influence upon one another.

It has been noted that young leaves of high water content favour infection and that an absence of moisture on the leaf surface is not unfavourable to successful infection. In order to study the conditions in nature under which "secondary" infection occurred, observation was kept on a number of trees for the spread of the disease from affected to healthy parts. When dissemination occurred, it was by means of conidia from infected leaf or blossom clusters which developed from infected buds.

Dispersal of the Disease in Relation to "Secondary" Infection.

The mildew apparent at bud-break is derived from hibernating mycelia established there during a previous season, and is rarely, if ever, due to infection from outside sources. The presence of mildew in spring, then, is dependent entirely upon the existence of infected buds and the number and distribution of these buds determine the severity of attack. Detailed observations on a number of trees showed no "secondary" infection or infection of tissues (blossoms, leaves, etc.) other than that which developed with the tissues arising from an infected bud. Although "secondary" infection plays a part in the distribution of the fungus, the importance of this phase in the life-history as a means by which the disease might extend and become more and more widespread in the plantation has been over-emphasised for normal conditions. Close observation for the appearance of "secondary" infection was kept on fourteen apple trees among which were the varieties Ribston Pippin, Sturmer Pippin, Mr Gladstone, Baumann's Reinette, Lord Derby, Cox's Orange Pippin, and Bismarck. These trees, which were two years old on Paradise stocks, were selected from a commercial nursery as being badly mildewed during the summer. They were

transplanted at Cambridge in the autumn. On leaf-fall the infected "one-year-wood" was easily distinguishable by its white coating of mycelium, and this retained sufficient contrast through the winter to provide sharp differentiation from uninfected wood.

The evidence is entirely opposed to the possibility of the spread of the disease by "secondary" infection. The year 1924, in which the observations were made, was not exceptionally mildew-free and conditions alleged to be typical for the spread of the disease obtained. In 1925 and early 1926 observations made were in keeping with those of the former year. Many examinations in the orchard constantly revealed that, in general, infections arose from and were entirely restricted to those portions of the tree mildewed the previous season, *i.e.* upon portions where buds harboured the fungus through the winter months. What appeared remarkable was that buds which did not harbour the fungus, although situated between infected buds on an infected twig, opened and remained entirely free from mildew throughout the summer.

Severe attacks of mildew are encouraged by the presence of new leaves and young shoots formed later in the summer as a result of a check in growth from some cause. This check may be brought about by a severe mildew attack resulting in a "die-back" or, which is a frequent occurrence in certain districts, an attack on the shoots by the capsid *Plesiocoris rugicollis* which encourages the formation of an excessive number of side shoots, especially on the extremely mildew-susceptible variety Lane's Prince Albert. The later-formed shoots arising from buds which would otherwise remain dormant are usually infected by conidia from the original shoot, if, indeed, they do not themselves arise in an infected condition from infected buds. In consequence, there appears to be a fresh outbreak and spread of the disease which, actually, is only the provision at the original centres of infection of fresh material sufficiently tender to encourage the disease into renewed activity. It is not denied that fresh infections take place, but it seems that, except where abundant new growth is encouraged late in the season, the spread of the disease by "secondary" infection has been generally over-estimated. On under-nourished or otherwise ill-treated trees in which growth has been induced late in the year the spread of the disease is sometimes noticeable.

III. External Symptoms of Leaf Attack with Observations on Accompanying Physiological Phenomena.

When a young leaf is heavily infected it never attains its normal expansion or shape but tends to be slightly or decidedly

dwarfed and somewhat elongated. Manaresi (17) found apple leaves affected by *P. leucotricha* to be thicker than healthy leaves. I have encountered suspected hypertrophy which might be offered in explanation of this phenomenon.

As early as June affected leaves become brittle. Conidia are then less evident, due to the drying of the leaf tissue and to the destruction of spores through the very rapacious habit of Cecidomyid* larvae. Browning of affected leaves soons sets in, usually at the tips, the discoloured area spreading gradually until the entire leaf becomes brown, giving an infected shoot the appearance shown in the photograph (Pl. XVI, fig. 2). The browning effect on leaves is not uncommon in parasitism by Erysiphaceae, notably in *Uncinula necator*, but nowhere else, perhaps, is this phenomenon so noticeable as when leaves are attacked by *P. leucotricha*: browning, resulting in the rapid death of the tissues, is one of the most destructive phases of this disease.

The premature death of the leaves—brought about directly or indirectly by mildew attack—has occupied my attention during the course of this investigation. The key to the problem, it is plain, lies hidden in the haustoria. In 1923 Neger (21), in *Erysiphe Cichoracearum* and *Sphaerotheca Humuli*, observed that leaves from certain host plants, when sown with conidia, assumed a spotted appearance over affected places. Numerous minute, reddish brown areas appeared, giving the impression that the leaves had been sprayed with corroding poison. The affected epidermal cells, on loss of turgidity, were observed to sink, appearing pit-like. Host plants not normally infected by the particular species or biological strain of the mildew under trial developed brown spots which were the result of the formation of masses of gum round the haustoria in the affected epidermal cells. Neger considered the spotting indicative of sub-infection.

Three causes of the severe browning and death of the leaves suggested themselves: (1) the adoption by the parasite of an endophytic habit; (2) the emission of a toxic substance by the fungus; and (3) the checking of respiration due to interference with gaseous exchange, and excessive transpiration through paralysis of stomata.

An abnormal endophytic habit, contracted in severe parasitism, might account for the rapid browning and death of affected leaves. It does not seem impossible to account for the adoption of an endophytic habit through an aggravated form of parasitism inasmuch as Salmon (33) has induced endophytic

* A species of *Mycodiplosis*, cf. Neger, F. W., Nat. Zeits. f. Land- und Forstwirts. XII (1915), 1.

attack by a mildew by wounding the host. In severe attack by *P. leucotricha*, mycelium was observed in the epidermis, palisade tissue and spongy parenchyma and sections also showed in these parts fungal organs strongly suggestive of haustoria. Preparations from natural and artificial infections showed mycelium within the inner tissues of the brown leaf, but no actual connection of hyphae to haustoria other than in the epidermal cells was found. The appearance of the host tissue suggested that the leaf, after becoming much weakened, had lost its power of resistance, and allowed easy access to the fungus. Klika (16) has recorded endophytic penetration by hyphae of *Erysiphe Polygoni*, *E. Cichoracearum*, *Uncinula Aceris*, *Trichocladia Astragali*, and *Sphaerotheca Humuli*, observed especially in older leaves in autumn. The abnormal endophytic habit of *P. leucotricha* might accelerate death, but the rôle played in this respect is not of great importance as it has been observed only in moribund or semi-moribund tissue. It seems probable therefore that endophytic penetration is the result and not the cause of severe parasitism of the leaves.

The emission of a toxic substance was next considered as a cause of ultimate death of the leaves. Sections through the junction of green and brown tissues revealed in the green tissue the formation of an apparently gummy substance which enclosed haustoria in the epidermal cells affected. Neger (*loc. cit.*) has called the entrapment thus brought about "encapsulation." The entrapment of the haustorium must arise from a reaction probably either toxic or enzymatic or both. The phenomenon has constantly been observed as a forerunner of browning. An early stage of "encapsulation" is illustrated in Pl. XVII, figs. 9 and 10. The nucleus of the haustorium becomes ill-defined, probably as a result of disorganisation following isolation of the haustorium from the host plant. Browning of palisade cells situated immediately below "encapsulated" haustoria often occurs; in the absence of the parasite it can only be assumed that a toxic substance has penetrated to these underlying cells. It is probable that the plant tissue, weakened by the continual withdrawal of food stores, succumbs to the toxin set up by "encapsulated" dead haustoria. The epidermal cells first lose their function; the toxin then spreads to the underlying tissues until, ultimately, all affected tissues die. Examinations showed a gradation in the number of entrapped haustoria according to the severity of browning of the leaf. In the dead leaf tissue the haustoria had succumbed, the cells had collapsed, and neighbouring invaded cells, if not themselves undergoing the same disorganising process, were rapidly killed either by the products of decomposition of adjoining dead cells or by a toxic substance

emitted by entrapped haustoria. In late stages of infection the attacked epidermal cells were filled with spherical, dark-coloured globules.

The checking of respiration due to interference with the gaseous exchange is probably a supplementary cause of browning. Stomata in leaves of the apple are entirely confined to the under surface, and when this is severely attacked, and dense conidial chains formed, the stomata are probably handicapped in the performance of their normal function. Transpiration would also be interfered with, but especially when guard-cells are parasitised and partially or totally paralysed. The dry, brittle nature of affected leaves may partly be due to excessive transpiration brought about by the sluggish action of the stomata.

IV. Results of Cross Inoculations of Different Varieties of Apples and Other Plants.

It was thought that so-called "biological species" might be present in *P. leucotricha* and that they might be limited to certain varieties of apples or to certain host plants. Experiments were conducted: (1) To discover to what extent "specialisation" existed in *P. leucotricha* occurring on apple, quince, and pear respectively. (2) To discover whether "strains" in mildew occurred on different apple varieties.

Conidia from the desired source were sown on leaves in a moistened Petri dish. In successful inoculations under suitable conditions conidial chains could be observed in six days. The following results were obtained from inoculations carried out on apple, pear and quince with conidia from each of these sources:

Host inoculated	Source of conidia	Date of inoculation	Date of prod. of conidiophores
1925:			
Quince	Lane's Prince Albert	May 30	June 5
,,	,,	,,	,,
1926:			
Quince	Cox's Orange Pippin	Apr. 15	Apr. 21
Cox's Orange Pippin	Quince	,,	,,
Pear	Cox's Orange Pippin	,,	,,
,,	Quince	,,	,,
Quince	,,	,,	,,
,,	Cox's Orange Pippin	Apr. 17	Apr. 24
Pear	Benn's Red	Mar. 7	Mar. 14
"Bridged" inoculations:			
Cox's Orange Pippin	Quince "bridged" by Cox's Orange Pippin	Apr. 30	May 6
,,	Cox's Orange Pippin "bridged" by Pear	,,	,,
,,	Quince "bridged" by Pear	,,	,,

From these results it is evident that conidia of *P. leucotricha* are capable of infecting each of the respective host plants mentioned, regardless of the source of conidia. Inoculations of pear leaves with conidia from the apple variety Lane's Prince Albert were unsuccessful later in the season (May 16th and June 6th, 1925), although, in a control, infection of healthy leaves of the same apple variety was vigorous. The rapid thickening of the cuticle of the pear leaf compared with that of the apple may explain this. No specialisation of parasitism is apparent. The infections resulting from the cross inoculations made did not suggest "sub-infection"; they were vigorous and in time became extensive. The infection power of conidia from such infections is not decreased as observed by the successful "bridged" inoculations above recorded.

It is interesting to note that under natural conditions in this country the pear is seldom attacked by *P. leucotricha*. The writer has in mind a large plantation of apples of various varieties interplanted with pears, which have constantly resisted the disease, though the apples were severely mildewed each season. Fisher (10), however, reported an outbreak of the disease on pears in 1921 in central Washington. He did not find the infections general but confined to "watersprouts" and "terminals." The mildew had been epidemic on apples interplanted since 1914. The morphological characters of the fungus on pears did not differ from those of the mildew on apple, but the general occurrence of perithecia on the fruit instead of on the twigs was noteworthy.

Although it was thought unlikely that "biological species" were present on the various apple varieties the following inoculations were carried out to prove it:

Host inoculated	Source of conidia	Date of inoculation	Date of infection
1925:			
Early Victoria	Early Victoria	July 15	July 21
,,	Mr Gladstone	,,	July 22
Mr Gladstone	Early Victoria	,,	Aug. 4
Cox's Orange Pippin	Cox's Orange Pippin	,,	,,
Worcester Pearmain	,,	,,	July 25
Cox's Orange Pippin	Mr Gladstone	,,	,,
1926:			
Beauty of Bath	Benn's Red	Apr. 7	Apr. 15
White Transparent	,,	,,	,,
Cox's Orange Pippin	Grosvenor	,,	Apr. 19
Worcester Pearmain	Benn's Red	,,	Apr. 15
Cox's Orange Pippin	Ribston Pippin	,,	,,
,,	Newton Wonder	,,	,,
,,	Early Victoria	,,	Apr. 19
,,	Sturmer Pippin	,,	Apr. 15
,,	Lord Derby	,,	,,
,,	Bismarck	,,	Apr. 19
,,	Worcester Pearmain	,,	,,

Inoculations during the latter part of July, 1925, and later were unsuccessful; the leaves had become more mature and presumably more resistant. It seemed safe from the number of positive infections recorded above that there existed in *P. leucotricha* no "races" specialised to certain varieties of apples.

V. Susceptible and Resistant Apple Varieties.

Apple varieties may be arranged in three categories according to susceptibility to mildew*. In the first category, those very susceptible, may be included Cox's Orange Pippin, Bismarck, Lane's Prince Albert, Allington Pippin, Stirling Castle, Newton Wonder, Early Julian and Annie Elizabeth. Among those more resistant are James Grieve, Beauty of Bath, Lord Grosvenor, Lord Derby, Mr Gladstone, Grenadier, Early Victoria, Jolly Miller, Charles Ross and Bramley's Seedling. In the third class, those highly resistant, Worcester Pearmain and Norfolk Beauty have been included. Other varieties could be added to the above categories, but reference has been made here only to those more commonly grown for commerce. Generally speaking, so-called Russian varieties of apples are more susceptible to attack and soft apple varieties are more susceptible than hard varieties. But above all, the soil, and general cultural practices, both of which determine the vigour of the tree, are largely responsible for epidemics and outbreaks of the disease.

Notes on Control Measures.

"Secondary" infection does not play a part of great practical importance in spreading the disease during the summer months, and therefore spraying solely to check the spread of the conidial stage of the disease cannot be recommended as an economical proceeding. Furthermore, no satisfactory spray fluid has yet been found which successfully controls the conidial stage of the fungus although Salmon (34) and others have recently used ammonium polysulphide with some success for the control of the conidial stage of another mildew. The writer carried out a number of preliminary trials with lime sulphur (1–60) in attempts to prevent early establishment of mycelium on young shoots which emerge from infected buds, or to kill such hyphae as had already become established thereon, and thus destroy the fungus at a vulnerable stage in its life history and prevent infection of axillary buds. A number of twigs of Lane's Prince Albert at Cambridge were individually sprayed at two fortnightly intervals during emergence, but in no case was the

* Acknowledgment is here made to Mr N. H. Grubb for corroboration and the inclusion of four varieties not personally observed by the writer.

mildew destroyed. In fact, a number of the treated twigs eventually bore dense masses of perithecia. At Evesham eighty trees of the apple variety White Transparent were similarly treated with a power mechanical sprayer using the same solution with the addition of arsenate of lead, but no obvious reduction in mildew was effected. The conidial stage on the leaves was not satisfactorily repressed or hyphae on the twigs destroyed.

Summary.

1. *Podosphaera leucotricha* perennates by means of hyphae and haustoria within dormant apple buds. Young axillary buds are invaded soon after their formation when the buds are inadequately protected by bud scales. Terminal and axillary buds on "one-year-wood" and blossom buds on spurs are most frequently invaded.

2. Only forty to fifty per cent. of mildewed twigs bear buds that open in an infected condition.

3. The perithecia are characterised by a depression: the apical appendages taper to a point and are non-septate.

4. The formation of perithecia is favoured by severe hyphal infection of the host in a young stage.

5. Water has a slight germinative influence on conidia. A dry healthy leaf in a turgid condition provides a substratum favourable to germination and rapid extension of infection.

6. Between 10 and 15° C. germination requires six hours. Freezing does not stimulate germination.

7. The penetration of the cuticular barrier appears to be by chemical rather than by mechanical action.

8. Two or more haustoria may be present in an epidermal cell. They are usually uninucleate.

9. "Secondary" infection has been over-emphasised; no general infection arises other than that which develops from infected buds.

10. Occasionally fresh foliage induced by "die-back" brought about by severe mildew attack or by the capsid *Plesiocoris rugicollis* extends infection.

11. A heavily infected young leaf never attains its normal development but tends to be dwarfed and somewhat elongated.

12. Browning of the leaves appears to be due principally to the death of tissues caused by toxins set up by encapsulated haustoria.

13. No "specialised races" were encountered. Conidia produced on different varieties of apple and on quince and pear are capable of cross infection.

14. Apple varieties vary in susceptibility.

15. The prevention of bud infection by spraying has not proved successful.

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EXPLANATION OF PLATES.

Plate XVI.

Fig. 1. A young shoot of Lane's Prince Albert severely attacked by *Podosphaera leucotricha*. ×⅔.
Fig. 2. Ditto, showing curling and dying of leaves. ×⅔.
Fig. 3. Blossom: infected (left) and healthy (right). ×⅔.
Fig. 4. Appearance after "setting" of fruit. ×⅔.

Plate XVII.

Fig. 1. Median L.S. through dormant leaf bud of infected terminal shoot of Cox's Orange Pippin, after removal of bud scales. ×25.
Fig. 2. Perithecia of *Podosphaera leucotricha* showing concave depressions and apical appendages.
Figs. 3–8. Haustorium formation of *P. leucotricha*. Fig. 3. Thickening of cuticle and depression of cell-membrane with outgrowth from hypha in cuticle. ×875. Fig. 4. Depression more pronounced. ×875. Fig. 7. Binucleate haustorium. ×1150.
Fig. 9. Encapsulated haustorium in enlarged epidermal cell. ×215.
Fig. 10. Ditto, showing disorganising nucleus of haustorium and barrier. ×875.

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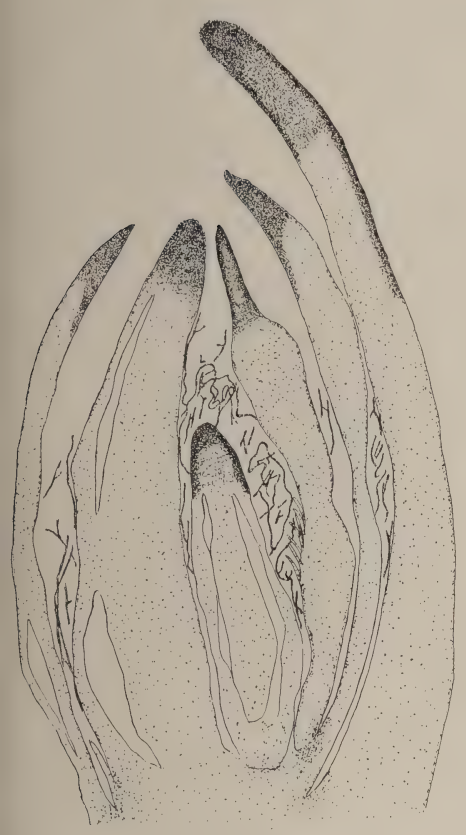
Podosphaera leucotricha



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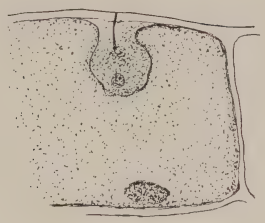

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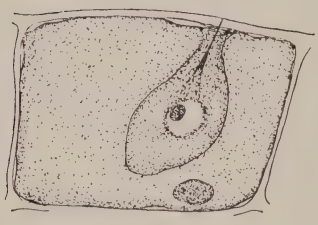

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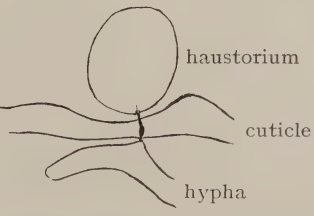

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Podosphaera leucotricha

APPENDIX TO "BRITISH BASIDIOMYCETAE."

ADDITIONS AND CORRECTIONS.

By Carleton Rea, B.C.L., M.A., Hon. Member British Mycological Society, etc.

FIVE years have now elapsed since the publication of my book on the *British Basidiomycetae.* During this period numerous additions have been made to the species enumerated in that work and several corrections are necessary after further investigation. It is somewhat curious that two of these additions should be due to American investigators, namely the record of *Leucogaster floccosus* Hesse by S. M. Zeller and C. W. Dodge, based on the specimen in Rabenhorst's Fungi Europeae exsiccati, no. 38, in the Farlow Herbarium at Harvard University; and the addition of *Peniophora miniata* (Berk.) Burt to Prof. E. A. Burt from Berkeley's British Fungi exsiccati, no. 251. The other additions and corrections are mainly due to the kindness of many friends, including the late W. B. Allen and his widow Mrs M. Joyce Allen, the Rev. J. Harvey Bloom, Miss C. A. Cooper, E. J. H. Corner, E. Metcalfe Day, Rev. E. A. Elliot, Miss J. C. Eyre, C. H. Grinling, St John Marriott, A. A. Pearson, J. Ramsbottom, Violet Rea, E. W. Swanton, and Miss E. M. Wakefield. To all of these I accord my heartiest thanks and more especially to E. J. H. Corner and A. A. Pearson.

In the following list I have indicated by an asterisk the position the species should have in the body of the work, and I have also emended the key to the divisions and genera of British Basidiomycetae.

Emend key to the divisions and genera of British Basidiomycetae as follows:

p. 4. HYMENOGASTRACEAE.

B. Peridium with external mycelial strands. Gleba cavities at first hollow. Spores elliptical, *smooth*	*Rhizopogon.*
Gleba cavities at first filled with a gelatinous mass. Spores hyaline or slightly coloured, *embedded in a gelatinous sheath,* globose or elliptical, *with various surface markings.*	*Leucogaster.*
p. 13. Add to *Hypochnus*: No cystidia	*Hypochnus.*
Like *Hypochnus* but with cystidia	*Tomentellina.*

p. 14. After *Epithele* add — *Epithele.*

Receptacle resupinate, effused, membranaceous, crustaceous or floccose. Hymenium smooth, farinose or pubescent. Spores white. Sterile mycelial hyphae (paraphyses) dichotomously branched, forming a rounded head beneath the basidia — *Asterostromella*

p. 16. After *Pistillaria* add — *Pistillaria.*

Receptacle minute, erect or pendant, somewhat firm, *pin-shaped*, stem cylindrical, smooth or villose, *enlarged at the apex into a convex disc covered by the hymenium*, which is sometimes ciliate at the margin. Spores white. Epiphytic or growing on dead leaves — *Pistillina.*

After **Auriculariales** add

1. Saprophytes with probasidia — SEPTOBASIDIINEAE.
2. Parasites with or without probasidia
3. Saprophytes without probasidia

SEPTOBASIDIINEAE.

Same characters as suborder — SEPTOBASIDIACEAE.

SEPTOBASIDIACEAE.

Receptable effused, floccose, or gelatinous, probasidium lateral — *Saccoblastia.*

p. 19. After *Tulasnella* add — *Tulasnella.*

Like *Tulasnella* but the hymenium provided with gloeocystidia — *Tulasnella* (sub-genus *Gloeotulasnella*).

Leucogaster (Hesse) Zeller & Dodge*.

(λευκός, white; γαστήρ, belly.)

Peridium globose, or irregular, fleshy or waxy; fibrils sometimes present, leading to rhizomorphs; thin, fragile, sometimes rupturing at maturity, sterile base absent. Gleba cells frequently polyhedral, *usually filled with spores embedded in a gelatinous mass*; septa homogeneous, with or without a distinct trama, *often gelatinizing at maturity*. Basidia subglobose to ovoid and subcylindric, mostly with 4- rarely 3- or 5-sterigmata. Spores

* *Leucogaster* and *Leucophlebs* in North America by S. M. Zeller and C. W. Dodge, Ann. Missouri Bot. Gard. XI, 389, 402.

hyaline or slightly coloured, with various surface markings, *embedded in a gelatinous spherical mass.* Hypogaeous or emergent.

27*. **L. floccosus** Hesse. Hesse, Bot. Centralbl. XL, t. 1, 2, figs. 1–9. *Floccus*, a flock of wool.

Pe. 2–4 cm., *light yellow*, bay to auburn in alcohol, irregular; fibrils *black or nearly so*, loose, round; with thick, flocculent, concolorous patches; epidermis 120–150 μ thick, composed of small hyphae, the outer coloured to a depth of 10 μ, the inner gelatinizing. Gleba *slightly darker*, waxy in preserved specimens; septa hyaline, 100–150 μ, composed of large, closely woven hyphae. Spores echinulate, globose, 4 μ in diam., with gelatinous sheath 7–10 μ in diam.; basidia 7 × 12 μ, with 2–3-sterigmata. Underground. Birch and oak woods. Aug.—Sept. Rare. Batheaston, C. E. Broome in Rabenh. Fung. Eur., 38, Farlow Herb. at Harvard Univ. as *Hymenogaster citrinus* Vitt.

56*. **Geaster Schmidelii** Vitt. non Massee. (= *Geaster nanus* Pers. sec. Hollós.) Hollós, Die Gasteromy. Ungarns, t. IX, figs. 7–11, as *Geaster nanus* Pers.

C. C. Schmidel, author of *Icones plantarum, etc.*

Exoperidium 1–3 cm., *whitish*, globose, splitting up into 5–8, unequal, acute lobes, divided up to about the middle, revolute, *brown inside* and becoming transversely cracked; endoperidium 4–10 mm., *brownish, or lead colour*, oval, or oblong, *shortly stipitate or subsessile.* Peristome prominent, long, conical, deeply sulcate, apex fimbriate. Stem ·5–2 × 2–4 mm., *pale yellowish*, cylindrical or compressed. Spores dark umber, verrucose, globose, 5–6 μ. Columella *paler*, oblong, half as high as the endoperidium or slightly higher. Capillitium brown, cylindrical, often rough and flexuose, 3–6·5 μ in diam. Sandy places and coniferous woods. Oct.—Nov. Rare. (*v.v.*)

59*. **Geaster minimus** Schwein. (= *Geaster marginatus* Vitt. sec. Hollós.) Lloyd, The Geastrae, figs. 50–52.

Minimus, smallest.

Exoperidium 1–2·5 cm., *white or ochraceous*, globose, splitting up into 5–9, unequal, acute lobes, divided to the middle, expanded, then recurved, *ochraceous* inside and slightly fleshy, flesh soon cracking and often peeling off; endoperidium 8–10 mm. in diam., 9–11 mm. high, *white or pale brown, often becoming blackish blue with age, oval*, pedicillate, *minutely granular*, then becoming smooth. Peristome conic, ciliate fimbriate, seated on a plane, circular disc. Stem 2–3 × 3–5 mm., *white*, cylindrical or compressed, *enlarged at the apex into an apophysis-like base to the endoperidium.* Spores fuscous, minutely warted, globose,

3·5–4·5 μ. Columella slender, nearly obsolete. Capillitium hyaline or yellowish, 3–4 μ in diam. Sandy pastures and amongst needles in coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

92*. **Pluteus Bullii** Berk.

This was dealt with as a variety of *Pluteus cervinus* (Schaeff.) Fr. in my *British Basidiomycetae* but I now consider it to be a distinct species. The cystidia *have no hooks at the summit*, are flask-shaped, 60–70 × 15–20 μ, apex 4–12 in diam., the spores are slightly smaller, 6–7 × 4–5 μ, and the whole facies of the fungus is really very different.

110*. **Pluteus luteovirens** Rea.

Luteus, yellow; *virens*, becoming green.

P. 2–4 cm., *deep honey-yellow tinged with green*, submembranaceous, convex, then expanded, *disc papillate and rugosely veined or wrinkled, striate from the disc to the margin*. St. 3·5–6 cm. × 2–5 mm., *white, shining*, equal or slightly attenuated upwards, *striate*, smooth. Gills *white, then flesh colour*, free, ventricose, 4–5 mm. wide. Flesh *white, yellow* at the thick disc and under the pellicle of the pileus, very thin at the margin. Spores pink in the mass, subhyaline under the microscope, globose or subglobose, 5–6 × 5 μ, multiguttulate. Cystidia abundant both on gill edge and surface, elongate-bottle-shaped, 35–50 × 14–17 μ, apex 5–7 μ in diam. Taste and smell none. Amongst moss on a stump of *Tilia cordata*. Aug. Rare. (*v.v.*)

128*. **Lepiota Pauletii** Fr. (= *Lepiota aspera* (Pers.) Quél. var. *Pauletii* (Fr.) Quél.) Barla, Champ. Alp. Marit. t. 15, figs. 12–15.

J. J. Paulet, author of *Traité des Champignons*.

P. 3–10 cm., *whitish tawny, covered with thin, pointed, darker coloured scales or warts*, convex, then plane. St. 4–6 × 1–3 cm., *whitish, or tinged with tawny*, attenuated upwards, base bulbous. Ring *white, or tinged with tawny*, membranaceous, *fugacious*. Gills *white*, free, crowded. Flesh *white, becoming yellowish*, thick at the disc. Spores white, oblong-elliptic, 6–8 × 3 μ. Smell strong, taste pleasant. Woods. May—Oct. Rare. (*v.v.*)

140*. **Lepiota echinella** Quél. & Bern. Trans. Brit. Myc. Soc. XI, t. 6.

ἐχῖνος, a hedgehog.

P. 1·5–2·5 cm., *bay, becoming split into areolate, thin, hairy, pyramidal, brown squamules, darker at the apex*, campanulate, then convex, umbonate. St. 3–4 cm. × 2–4 mm., *rose or amethyst colour, sprinkled with blackish brown scales near the base*, equal. Ring arachnoid, silky, fugacious. Gills *whitish cream* colour, sometimes becoming stained with red, free, crowded,

2–3 mm. wide. Flesh *white, reddish in the stem,* thin. Spores white, pruniform, 4–7 × 2·5–3·5 μ. Smell of radish. Amongst dead leaves. Sept.—Oct. Not uncommon. (*v.v.*)

193. **Psaliota sylvicola** (Vitt.) Fr.

Spores brownish purple, broadly elliptical, 6–6·5 × 4–4·5 μ, with a large central gutta and oblique apical germ-pore.

207. **Anellaria fimiputris** (Bull.) Karst.

Spores purple-black, oblong-elliptical, 14–17 × 8–9 μ. Cystidia cylindrical or fusiform, often flexuose, 45–55 × 8–15 μ, apex 3–7 μ in diam.

261. **Armillaria mucida** (Schrad.) Fr.

Patouillard and Ricken state that there are no cystidia in this species, but there are abundant, hyaline cystidia, fusiform or cylindrical, 90–140(–180) × 15–25–30(–45) μ.

352*. **Cortinarius (Phlegmacium) intermedius** Rea.
Intermedius, intermediate.

P. 5–8 cm., *whitish, then clay colour, disc becoming ochraceous with age*, fleshy, compact, convex, then flattened, viscid, with a few innate darker fibrils; margin *white*, incurved, exceeding the gills. St. 5–6 × 1–1·5 cm., *white*, equal, base marginately bulbous, adpressedly fibrillose. Cortina *white*, fibrillose, fugacious. Gills *white, then clay colour*, emarginate, crowded, thin; edge finally paler, minutely serrulate. Flesh *white*, with a horn-coloured line at the base of the gills, becoming tinged with blue at the apex of the stem on section, compact, thin at the margin of the pileus. Spores ferruginous, verrucose, oblong or broadly elliptical, rounded at both ends, 9–10 × 5–6 μ. Basidia 25–30 × 8–9 μ, with 4-sterigmata. Smell strong, of starch. Taste mild. Woods, under oaks and nuts. Sept. Uncommon (*v.v.*)

393*. **Cortinarius (Myxacium) epipolius** Fr. Fr. Icon. t. 150, fig. 3. ἐπιπόλιος growing hoary.

P. 4–8 cm., *bluish grey tinged with yellow*, fleshy at the disc, thin elsewhere and submembranaceous, slightly viscid, convex, then plane, gibbous, glabrous, *silky-shining with an innate hoariness*. St. 7–8 × 1 cm., *whitish, becoming violet*, viscid, base clavately bulbous, elastic. Cortina fugacious. Gills *cinnamon*, decurrent, 6–8 mm. broad, broadest behind, subdistant. Flesh whitish, fuscous under the cuticle of the pileus, spongy in the stem. Spores ferruginous, subglobose, 8–9 × 6–7 μ, contents granular. Woods. Sept.—Oct. Rare. (*v.v.*)

441*. **Cortinarius (Dermocybe) Queletii** Bataille. Boud. Icon. t. 115, as *Cortinarius orellanus* Fr.
Lucien Quélet, the eminent French mycologist.

P. 2–4 cm., *tawny red, or brick-red*, fleshy, campanulate, then expanded and slightly depressed, covered with adpressed fibrils; margin slightly lobed. St. 3–8 cm. × 4–7 mm., *yellowish, tinged with red from the more or less crowded, red, fibrillose squamules*, base slightly thickened. Gills *lemon-yellow, then rust colour*, adnate, 4–6 mm. broad, subdistant. Flesh *pale, lemon-yellow in the stem*, thin at the margin. Spores ferruginous, oblong-oval, very minutely verrucose, 10–12 × 5–6 μ. Deciduous woods and charcoal heaps. Sept.—Oct. Uncommon. (*v.v.*)

541*. **Inocybe pseudofastigiata** Rea. (= *Inocybe fastigiata* Schaeff. sec. Rick.)

ψευδής, false; *fastigiata*, the species *I. fastigiata*.

P. 3–9 cm., *yellowish brown, or straw colour*, slightly fleshy, conico-campanulate, then expanded *with a prominent umbo*, longitudinally fibrillose and cracked; margin often irregularly split or torn, cortina pale, soon evanescent. St. 4–10 cm. × 4–15 mm., *pale, or brownish*, equal, or slightly attenuated upwards, often irregular or curved, fibrillose or subfloccose, apex obsoletely mealy. Gills *olive-yellow, then olive-brown*, sinuato-free, ventricose, somewhat crowded; edge often white floccose. Flesh pale, thin. Spores ferruginous, elliptical, often depressed on one side, with an oblique basal apiculus, 10–12 × 6–8 μ. Cystidia only on gill edge, cylindrical or clavate, more rarely ventricose or compressed near the apex, 40–55 × 8–17 μ ("50–60 × 15–20 μ" sec. Rick.); apex 6–10 μ in diam., obtuse. Coniferous and frondose woods. July—Oct. Not uncommon. (*v.v.*). *Inocybe fastigiata* (Schaeff.) Fr. has *no cystidia*, and the quotation from Ricken respecting the cystidia should be deleted from the description of this species on page 207 of *British Basidiomycetae*.

559. **Inocybe lacera** Fr.

Spores brown, oblong, obtuse, 12–16 × 5–6 μ. Cystidia fusiform, ventricose, 60–80 × 14–20 μ, numerous, apex brownish, muriculate, 6–9 μ in diam.

570. **Inocybe relicina** Fr. *Relicina*, curled backwards.

P. 2·5–4 cm., *fuliginous, or reddish brown*, fleshy, thin, conical, then expanded, obtuse, *everywhere scaly-squarrose with fasciculate down*; margin sometimes split or lobed. St. 4–7 cm. × 5–8 mm., *fuliginous, or reddish brown*, equal, fibrillose, *floccoso-scaly*, apex white-mealy. Gills *pale, then olivaceous and often finally ferruginous*, adnexed, crowded, edge white. Flesh of stem *reddish*. Spores ferruginous in the mass, pip-shaped, 10–12 × 6–7 μ. Cystidia cylindrical, ventricose, 60–80 × 13–17 μ. Smell and taste none. Damp pine woods amongst *Sphagnum*, and in bogs. July—Oct. Uncommon. (*v.v.*)

601*. **Astrosporina umbrina** (Bres.) Rea. (= *Inocybe umbrina* Bres.) Bres. Fung. Trid. t. 55, as *Inocybe umbrina* Bres. *Umbrina*, umber-coloured.

P. 2–3·5 cm., *chestnut-brown*, fleshy, campanulato-convex, then expanded and umbonate, *somewhat viscid*, fibrillosely villose, then becoming very rimose, disc sometimes verruculose, at first covered with a very distinct *greyish fuscous* veil. St. 4–6 cm. × 3–5 mm., *subconcolorous*, subbulbose or subturbinately bulbose, base pilose, apex white-mealy. Gills *lurid citron-yellow, then rufescent-cinnamon*, edge *darker* (sometimes paler sec. Rick.), attenuated behind, or sinuato-adnate, crowded. Flesh *lurid*. Spores yellowish under the microscope, substellate, 7–8 × 5–6 μ. Cystidia fusiform, ventricose, 60–70 × 14–18 μ, somewhat fuscous and muriculate at the apex. Smell and taste none. Woods. July—Nov. Not uncommon. (*v.v.*)

632*. **Tricholoma guttatum** (Schaeff.) Rea. (non *Tricholoma guttatum* (Schaeff.) Fr., nec Quél.). Schaeff. Icon. t. 240. Cke. Illus. no. 76, t. 59. *Guttatum*, spotted.

P. 4–7 cm., *pale yellowish, becoming rosy towards the margin, covered with minute, brownish squamules, especially at the disc*, fleshy, convex, then flattened; margin involute, *often irregular and lobed*. St. 4–6 cm. × 8–12 mm., *white*, equal, attenuated at the base, smooth. Gills *grey, then tinged with rose*, emarginate, ventricose, 5–10 mm. broad, somewhat veined, distant; *edge uneven, undulate*. Flesh *white, becoming tinged with red when cut*, firm. Spores white, broadly elliptical, often depressed on one side, 5–6 × 4 μ, with a large central gutta. Smell and taste none. Amongst dead leaves under oaks in woods. Oct. Rare. (*v.v.*)

634*. **T. impolitum** (Lasch) Fr. *Impolitum*, unpolished.

P. 6–10 cm., *ochraceous, variegated with bistre or brownish black*, fleshy, convex, obtuse, *then subdepressed*, floccosely fibrillose, *becoming broken up into squamules*, disc subgranular; margin *white*, involute, *villose*, becoming smooth. St. 6–7 × 1·5–2 cm., *white*, equal, firm, fibrillose, *apex floccosely squamulose*. Gills *whitish*, emarginate, crowded, 6–8 mm. broad. Flesh *white*, compact. Spores white, broadly elliptical, with a basal apiculus, 5–6 × 4 μ, with a large central gutta. Smell none. Taste somewhat acrid, then peppery. Deciduous woods on calcareous soils, often growing in rings. Sept.—Nov. Uncommon. (*v.v.*)

670*. **Tricholoma sulphurescens** Bres. (= *Tricholoma resplendens* Fr. sec. Quél.) *Sulphurescens*, becoming sulphur yellow.

P. 2·5–8 cm., *white, becoming yellowish with age and somewhat fuscous especially at the margin* ("*pale wash-leather colour, becoming whitish with subochraceous spots*" Bres.) fleshy, convex, then flattened, obtuse, *floccose* ("silky, then glabrous, dry" Bres.); margin *thin*, exceeding the gills ("sulcate with age" Bres.). St. 2–8 × 1–2 cm., *white, becoming sulphur-yellow, especially at the base on handling*, equal, base somewhat incrassated or rooting, apex *white-mealy, punctate with tawny, fuscous squamules* towards the base. Gills *white, becoming sulphur-yellow when bruised, and finally pallid*, sinuato-adnexed, rounded behind and almost free, *very narrow*, 2 mm. broad, *densely crowded*, often furcate at the base and sometimes higher up, edge acute. Flesh *white, becoming sulphur-yellow when broken*, compact, thick at the disc, very thin at the margin. Smell none ("foetid, like *Tricholoma sulphureum*" Bres., "fruity" Quél.). Taste somewhat bitter ("mild then slightly peppery" Bres.). Spores white, broadly elliptical or subglobose, bluntly apiculate, 5–8 × 3·5–5 μ ("5–6 × 4·5–5 μ" Bres.), punctate; basidia clavate, 20–28 × 5–6 μ ("30–35 × 8–9 μ Bres.), with 4-short-sterigmata. Cystidia none. Amongst beech leaves, under beeches and conifers. Oct. Rare. (*v.v.*) A very distinct species from *Tricholoma resplendens* Fr. in the description of which (no. 616) the statement "becoming yellowish externally and internally" should be deleted.

704*. **Tricholoma turritum** Fr. *Turritum*, turreted.

P. 5–14 cm., *fuliginous purple when moist, becoming grey when dry*, fleshy, *conico-campanulate, then expanded, acutely umbonate*, smooth; margin inflexed and finally somewhat split. St. 7–13 cm. × 8–20 mm., *white, becoming fuscous with the fibrils*, subequal, *fragile, base thickened* and white villose. Gills *white*, adnexed, *separating*, ascending, ventricose, crowded, distinct; *edge often delicately serrulate*. Flesh *watery, becoming white*, fragile, soft. Spores white, elliptical, 7–8 × 4–5 μ, with a large gutta, punctate. Damp places and on leaf mould in woods. Sept.—Oct. Uncommon. (*v.v.*)

748. **Entoloma majale** Fr.

I agree with Konrad in transferring this species to *Nolanea* and will deal with it as no. 1288* *Nolanea majalis* (Fr.) Konrad.

769*. **Hebeloma anthracophilum** R. Maire. Gill. Champ. Fr. t. 364, as *Flammula carbonaria*.

ἄνθραξ, charcoal; φίλος, loving.

P. 4–5(–7) cm., *fulvous, disc becoming fuscous*, campanulate or hemispherical, then expanded, more or less umbonate, glabrous, viscid, *pruinose with innate grey fibrils*; margin at first involute, white-tomentose, then expanded and floccose.

St. 5–8 × ·5(–1) cm., *white*, straight, cylindrical, silky with white fibrils and rough with concolorous squamules. Cortina none. Gills *whitish, then clay colour, at length ferruginous fuscous*, sinuato-adnate, or uncinate, ventricose, crowded; edge *whitish*, hardly denticulate. Flesh *whitish, firm, elastic*. Spores ferruginous fuscous in mass, pruniform, 10–11 × 6 μ, verruculose. Basidia cylindric-clavate, with 4- rarely 2-sterigmata. Cystidia none. Edge of gills with a few hairs, little differentiated. No smell of radish. Taste *instantaneously very bitter*. Charcoal heaps. Sept.—Nov. Not uncommon. (*v.v.*)

790*. **Hypholoma radicosum** Lange. (= *Hypholoma epixanthum* Rick. sec. Lange, *Flammula inopus* Rea, Brit. Basid. no. 998.) Cke. Illus. no. 484, t. 446, as *Flammula inopus* Fr. *Radicosum*, having a root.

P. 3–9 cm., *honey-tan, or reddish tan, paler round the margin from the white, silky veil*, fleshy, convex, then expanded, obtusely umbonate, or subgibbous, *at first covered by the white silky veil*, then becoming smooth. St. 7–25 cm. × 4–10 mm., *white above, brick colour below*, equal, or slightly enlarged before continuing *into the long, tapering, rooting base*, tough, flexuose, *apex mealy and white fibrillose, fibrillosely scaly below with subferruginous, subimbricate or transversely zone-like scales*. Gills *pale yellowish, or pallid, sometimes green, then becoming purplish*, adnate, emarginate, 6–7 mm. broad, thin, crowded; edge *white*, floccose. Flesh *yellowish, ferruginous in the stem*, thin at the margin. Spores purple, broadly elliptical, 6·5–8 × 4–5 μ, 1-guttulate. Cystidia bottle-shaped, 35–40 × 7–11 μ, apex 2–4 μ in diam. Smell very strong. Taste very bitter. Solitary, or caespitose. Coniferous, rarely frondose stumps. May—Dec. Not uncommon. (*v.v.*)

802. **Hypholoma catarium** Fr. *Catarium*, belonging to a cat.

P. 1·5–2·5 cm., *deep honey-yellow, becoming date-brown with age*, fleshy membranaceous, hemispherical, then expanded, *smooth*, hygrophanous; margin appendiculate with the white veil, striate, incurved, exceeding the gills. St. 1–2·5 cm., *whitish, rather* shining, somewhat silky, *firm, base incrassated* and white floccose, apex striate, *pruinose*. Gills *white, then fuscous*, adnate, narrow, rather crowded. Flesh *concolorous, becoming whitish*, thin. Spores fuscous purple, elliptic-oblong, 5–6 × 3–3·5 μ, multiguttulate. Gregarious or subcaespitose. Amongst grass in parks and roadsides, and on sawdust heaps. Sept.—Oct. Not uncommon. (*v.v.*)

843*. **Clitocybe pseudoconglobata** Rea.
ψευδής, false; *conglobata*, the species *Clitocybe conglobata*.

This species has exactly the same macroscopic characters as *Clitocybe conglobata* (Vitt.) Bres., including the white pruinose, involute margin, but differs in the white, *oblong* spores, with an oblique apiculus, 9–11 × 3·5–4 μ. Apple pulp refuse. Dec.—Jan. Uncommon. (*v.v.*)

871*. **Clitocybe fritilliformis** (Lasch) Fr.
Fritillus, a dice-box; *forma*, shape.

P. 3–5 cm., *dark brownish olive, greyish olive, or pallid grey, becoming fuscous when dry*, fleshy membranaceous, convex, umbilicate, then infundibuliform, *very firm*, glabrous, often rugulose; margin smooth, translucidly striate, flexuose, incurved, often sublobate. St. 3–7 cm. × 4–12 mm., *concolorous, generally clothed with white, silky threads*, more rarely flocculose, becoming smooth, enlarged upwards when growing singly, downwards when fasciculate, striate, base white villose, soon hollow, *remarkably tough*. Gills *pallid, pale yellowish, then greyish red*, decurrent, *often branched and anastomosing*, narrow, 2–4 mm. broad, *somewhat thick*, crowded. Flesh *concolorous*, thick only at the disc, *remarkably tough*. Spores white, oblong elliptic, with an oblique apiculus, 7–9 × 3–3·5 μ. Smell unpleasant or sometimes earthy. Taste unpleasant. Growing singly, fasciculately or in rings, amongst mossy grass, leaves, twigs or conifer needles in woods and pastures. Sept.—Nov. Rare. (*v.v.*)

873*. **Clitocybe vibecina** Fr. Rick. Die Blatterpilze, t. 103, fig. 5. *Vibecina*, striped.

P. 2·5–7 cm., *livid grey, becoming almost white when dry, submembranaceous*, convex, *umbilicate*, then infundibuliform, hygrophanous, glabrous, often with a silky sheen and somewhat zoned; margin *soon patent, striate* when moist. St. 5–7·5 cm. × 4–7 mm., *greyish, paler at the apex*, equal, sometimes compressed, elastic, often *flexuose*, base white villose. Gills *greyish white*, adnate, *then deeply decurrent*, 2–3 mm. broad, *somewhat crowded*. Flesh *greyish when moist, white when dry*, thick at the disc, thin at the margin. Spores white, elliptical, 5–7 × 3–4 μ. Smell earthy, mealy or none. Taste mild or slightly unpleasant. Woods, especially conifers. Not uncommon. (*v.v.*)

931*. **Hygrophorus lepidopus** Rea. λεπίς, a scale; πούς, foot.

P. 4 cm., *pale ochraceous, everywhere covered with minute, adpressed, bistre scales*, fleshy, convex, obtuse, then expanded; margin *exceeding the gills*, undulate, rimosely incised. St. 6–7 × 1 cm., *white, the basal three-fourths covered with minute, adpressed, bistre scales*, firm, tough, equal, or slightly enlarged upwards, apex white-mealy. Gills *white, or pallid*, sinuato-adnate, ventricose, 5–6 mm. broad, distant; trama consisting

of interwoven hyphae. Flesh *white*, thick at the disc, thin at the margin. Spores white, subglobose, 5–5·5 × 4–4·5 μ; basidia elongate-clavate 45–50 × 5–7 μ, with 4-sterigmata, 4–6 μ long. Cystidia none. Smell none. Taste pleasant. Pastures. Sept.—Oct. Rare. (*v.v.*)

998. **Flammula inopus** Fr. (= *Flammula fusus* (Batsch) Fr. sec. Quél., and Rick.) ἴς, a fibre; πούς, foot.

P. 5–10 cm., *honey-tan colour, paler round the margin*, fleshy, convex, then expanded, obtuse, slippery (almost viscid) when moist, and *smooth* when dry. St. 7–10 cm. × 2–4 mm., *pallid, brick colour downwards*, equal, or attenuated upwards, tough, flexuose, *adpressedly fibrillose*. Cortina fugacious. Gills *pale yellowish white, sometimes green*, adnate, linear, thin, crowded. Flesh *concolorous, becoming whitish, ferruginous in the stem*, thin at the margin. Spores dirty-ferruginous, "subelliptical, 8–9 × 4–5 μ. Cystidia flask-shaped or clavate with a prominent point, 30–36 × 10–15 μ, filled with olive-yellow juice" Rick. Solitary or caespitose. Pine trunks, stumps and on the ground. Sept.—Nov. Uncommon.

In my *British Basidiomycetae* I followed the tradition of many British mycologists and founded my description of this species on *Hypholoma radicosum* Lange (see p. 213 hereof) which has hitherto been erroneously referred to this species and consequently a redescription of *Flammula inopus* became necessary.

999*. **Flammula austera** Fr. αὐστηρά, bitter

P. 4–12 cm., *honey colour, becoming fuscous or tawny at the disc*, fleshy, campanulate, then convex and expanded, obtuse, *sprinkled with superficial fibrils*, then smooth, *hygrophanous*. St. 10–12 × 1 cm., *whitish, fibrillosely silky, becoming ferruginous* when the fibrils are worn away, equal. Cortina *white*, shining, appendiculate. Gills *cinnamon from the first*, adnate, subdecurrent, 10–12 mm. broad, crowded. Flesh whitish, thin at the margin. Spores ferruginous, oblong-elliptical, with an oblique apiculus, 8–9 × 4–5 μ, contents granular. Cystidia none. Taste acid, smell "very acid" Fr. Densely caespitose. Pine trunks and on the ground. Oct. Rare. (*v.v.*)

1024*. **Collybia infumata** (Bres.) Rea. (= *Clitocybe ectypa* Fr. var. *infumata* Bres.) Bres. Fung. Trid. t. 154, as *Clitocybe ectypa* Fr. var. *infumata* Bres. *Infumata*, smoked.

P. 4–7 cm., *whitish becoming fuscous, fuscous brown or fuscous fawn colour*, fleshy, convexo-campanulate, then expanded and umbonate or depressed, *innately fibrillose*, often reticulately fibrillose, disc punctate. St. 5–7 cm. × 6–15 mm., *whitish becoming fuscous*, equal, often becoming thickened and white

villose at the base, fibrillose. Gills *whitish, then greyish, becoming blue when touched*, adnate or sinuate, then subdecurrent, somewhat crowded. Flesh *white, becoming black* when broken, thin at the margin. Spores white, boat-shaped or subrhomboidal, ends obtuse, 9–12 × 6–8 μ, 1–guttulate. Smell and taste none. Woods and under beeches. July—Oct. Uncommon. (*v.v.*)

1226*. **Mycena lasiosperma** Bres. Bres. Fung. Trid. t. 37, fig. 1. λάσιος, shaggy with hair; σπέρμα, seed.

P. 1–2·5 cm., *livid grey, becoming somewhat yellowish, disc darker*, membranaceous, conico-campanulate, then expanded and umbonate, and finally revolute, *subviscid, at first covered with grey pruina*, becoming smooth, striate up to the umbo; margin entire, finally revolute. St. 3–4 cm. × 1–2 mm., *pallid*, "chestnut colour downwards" Bres., equal, firm, *gradually tapering downwards into the white villose, rooting base, everywhere white pruinose*. Gills *white, then greyish*, sinuato-uncinate, somewhat crowded, connected by veins. Flesh *white or subconcolorous*, thin. Smell none, or "of rancid meal" Bres. Spores white, *globose*, 5–7 μ, *verrucose*; basidia clavate, 25–35 × 7–8·5 μ, with 2-long-sterigmata. Cystidia on both gill edge and surface, elongate fusiform, ventricose below, narrowly cylindrical above, 40–95 × 5–13 μ ("40–55 × 8–14 μ" Bres.), apex obtuse, rarely somewhat branched, 2–3·5 μ in diam. Often caespitose. On stumps in woods and living mulberry trees. Oct.—Dec. Uncommon. (*v.v.*)

1277*. **Mycena trachyspora** Rea. τραχύς, rough; σπορά, seed.

P. 6–17 mm., *livid grey, or pale fuscous*, membranaceous, campanulate, then expanded, and hemispherical; margin slightly striate, often split. St. 1–3 cm. × 1–2 mm., *white, or pallid*, equal, *clothed*, under a lens, *with very delicate, hyaline, aseptate, cystidia-like hairs*, 50–70 × 6–10 μ, apex obtuse, 8–15 μ in diam. Flesh *white*, thin. Spores white, *globose or subglobose*, 5–6 × 4·5–5 μ, *verrucose*. Basidia clavate, 20–22 × 7 μ, with 4-sterigmata. Cystidia hyaline flexuose, often ventricose at base, 45–60 × 6–10 μ, apex obtuse, sometimes constricted into a globose head, 6–7 μ in diam. Old elm root. Oct.—Nov. Rare. (*v.v.*)

1288*. **Nolanea majalis** (Fr.) Konrad. Bull. Soc. Myc. Fr. XXXIX, t. 2, figs. 1–4. *Majus*, the month of May.

P. 4–9 cm., *cinnamon, or brown, becoming paler, or ochraceous when dry*, fleshy membranaceous, *conico-campanulate*, then expanded, umbonate, silky-shining when dry; margin striate when moist. St. 7–16 cm. × 4–6 mm., *greyish tawny, paler than the pileus*, shining, *twisted, striate*, somewhat fibrillose, apex farinose,

often connate at the thickened, white tomentose base. Gills *greyish*, then flesh coloured with the rosy spores, sinuato-adnate, then free, *ventricose*, 8–14 mm. broad, rather crowded, crenate. Flesh pale, very thin. Spores pink, oblong angular, 12–16 × 7–9 μ. Smell and taste often unpleasant, of fish. Heaths and coniferous woods. April—June. Uncommon. (*v.v.*)

1293*. **Nolanea cetrata** (Fr.) Schroet. Ricken, Die Blatterpilze, t. 74, fig. 1. *Cetrata*, shield-bearing.

P. 2–7 cm., *bright yellow, or yellowish cinnamon, then pale ochraceous, or greyish ochraceous when dry*, submembranaceous, campanulato-plane, then convex and expanded, obtuse, glabrous, pellucidly striate when moist, silky-shining when dry; margin *often crenulate*. St. 5–8 cm. × 2–7 mm., *pale yellow, or pale brownish ochre*, base white tomentose, subattenuated upwards, often contorted or compressed, *silky, fibrillosely striate*, brittle. Gills *yellowish flesh colour, then brown reddish flesh colour*, adnate by a tooth, nearly free, ventricose, 6–7 mm. broad, subdistant; edge *subcrenulate, becoming brownish*. Flesh watery, *very brittle*. Spores pink, oblong, mostly sexangular, 10–12 × 5–7 μ; basidia with 2–4-sterigmata ("2-sterigmata only" Schroet. and Rick.). Coniferous woods, rarely beech woods and in gardens. Aug.—Oct. Uncommon. (*v.v.*)

1407*. **Omphalia candida** Bres. Bres. Fung. Trid., t. 199. *Candida*, shining white.

P. 6–18 mm., *shining white*, membranaceous, convex, then expanded, often papillate, smooth; margin pellucidly striate. St. 4–7 cm. × 1–2 mm., *concolorous*, equal, very minutely pruinose, fibrillosely-splitting, rooting base white floccose. Gills *concolorous*, deeply decurrent, distant, veined at the base. Flesh white. Spores white, fusiform, ventricose, acute at one end, obtuse at the other, 7–10 × 3–4 μ, 1-guttulate; basidia clavate, 20–25 × 6–8 μ. Smell and taste none. On dead rhizomes of *Symphytum officinale*. Oct. Uncommon. (*v.v.*)

1411*. **Omphalia gibba** Pat. *Gibba*, a hump on the back.

Entirely white, very fragile. P. 2–4 mm., membranaceous, plane, disc gibbose, "villose and soon becoming deeply depressed" Pat., diaphanous. St. 4–6 × ·5 mm., villose, pellucid. Gills ·5–1 mm. broad, *often absent, or reduced to folds*. Spores white, oblong elliptic, attenuated at one end, straight or slightly curved, 9–12 × 3–3·5 μ ("12–15 × 3–5 μ" Pat.), basidia pyriform 6–10 × 5–6 μ, with 2–4-sterigmata, 6–7 μ long. Cystidia none. On *Cladium Mariscus, Carex, Scirpus, Sparganium* in fens and marshes. Nov. Uncommon. (*v.v.*)

1448. **Pleurotus revolutus** Kickx.

Spores white, elliptical, 6–7 × 3·5–4 μ, 2–3-guttulate.

1450*. **Pleurotus geogenius** (DC.) Fr. (= *Agaricus auricula* Pers.) Rolland, Champ. t. 44, no. 96.

γῆ, earth; γίγνομαι, to be born.

P. 3–6 cm., *pale grey, yellowish, or bistre,* fleshy, then subcoriaceous, erect, *semi-infundibuliform and incised on one side, or spathulate,* smooth, glabrous; margin at first involute, then undulato-reflexed or lobed. St. 1–6 cm. × 5–20 mm., *whitish,* lateral, *erect, strigosely white-tomentose,* base attenuated or bulbous, with numerous white, string-like mycelial threads. Gills *white, then subalutaceous,* decurrent, crowded, narrow, sometimes forked. Flesh *white, with a gelatinous layer under the cuticle of the pileus.* Spores white, obtusely elliptical, often apiculate at the base, 7–8 × 5 μ, 1–2-guttulate. Cystidia *very abundant on the surface of the gill,* hyaline, fusiform, 50–80 × 12–16 μ, apex obtuse, 4–5 μ in diam., very thick walled, often rough at the apex. Smell *strong of new meal.* Taste pleasant. Edible. Often densely caespitose. On the ground in woods and on sawdust heaps. Aug.—Oct. Locally common. (*v.v.*)

1537*. **Russula constans** (Karst.) Romell (= *Russula flava* Romell sec. Kauffman; non *Russula constans* Britz.)

Constans, unchangeable.

P. 5–10 cm., *apricot colour with a tinge of pink round the margin, then yellow* (luteus), convex, then expanded, often becoming depressed in the centre, viscid; pellicle separable, possessing cystidia; margin thin, striate. St. 4–8 × 1–3 cm., *white, becoming cinereous or blackish with age,* equal, or slightly incrassated at the base, somewhat striate. Gills *cream colour, becoming cinereous or blackish when dried,* adnate, broad in front, attenuated behind, 8–12 mm. broad, forked at the base, connected by veins, somewhat crowded. Flesh *white, soon becoming brownish and finally cinereous or blackish.* Spores *pale cream colour in the mass,* subglobose, or broadly elliptical, 9–12 × 7–9 μ, verrucose; basidia clavate, 25–39 × 8–9 μ ("35–38 × 10–11 μ" Karst.), with 4-sterigmata, 3–4 μ long. Cystidia abundant, elongate-flask-shaped, cylindrical or more rarely fusiform, 28–55 × 5–13 μ ("65–72 × 11–12 μ" Karst.), apex 2–3 μ in diam., contents yellowish. Smell none. Taste *mild.* Moist places in deciduous and coniferous woods. Aug.—Oct. Not uncommon. (*v.v.*)

1546*. **Russula paludosa** Britz. Britz. Hym. Südbay. Russula, nos. 23, 60, 96.

Paludosa, marshy.

P. 3·5–12 cm., *red, reddish orange or purplish copper colour*, rarely becoming decoloured and *greenish yellow at the margin or at the disc*, convex, sometimes umbonate, then plane and depressed, slightly fleshy, *viscid, pellicle separable* or only so to the disc; margin rounded, *generally tuberculosely sulcate*, or only striate when old. St. 5–15 × 1·5–2·5 cm., *white tinged with rosy purple, or entirely white, attenuated at the apex*, widening out at the base of the gills, gradually enlarged downwards to almost twice its breadth at the base, pruinose when young, more or less rugosely striate. Gills *white, then ochraceous from the spores, often coloured reddish on the edge near the margin of the pileus*, free or almost free, rounded in front, attenuated behind, equal, rarely unequal, often furcate near the margin, broad, thin, rather crowded. Flesh *white, slightly reddish under the cuticle of the pileus*, firm, brittle, then soft and fragile. Spores *cream colour in the mass*, pale yellowish under the microscope, elliptical, or oblong, 8–12(–14) × 7–9 μ, *echinulate, sometimes marked with ridges*, 1-guttulate. Cystidia clavate, 60–100 × 8–11 μ. Smell weak. Taste mild, or often slightly acrid when quite young. Coniferous woods and peat bogs. June—Nov. Uncommon. (*v.v.*)

1562*. **Lactarius resimus** Fr. Fr. Icon. t. 168, fig. 1.
Resimus, bent back.

P. 7–13 cm., *pallid, or pale ochraceous, becoming yellowish with age*, fleshy, convex, umbilicate, then infundibuliform, very viscid, *smooth*, zoneless; *margin involute, white tomentose*, then expanded and smooth. St. 3–4·5 × 2–3·5 cm., *concolorous*, somewhat attenuated at the base, villose, very finely pubescent under a lens. Gills *whitish*, decurrent, 5–8 mm. broad, somewhat crowded. Flesh *pallid, becoming yellow when broken*. Milk *white, becoming immediately deep sulphur-yellow* when exposed to the air. Spores *ochraceous*, globose, 6–7 × 6 μ, obtusely echinulate, 1-guttulate. Taste acrid. Woods on calcareous soil. Aug.—Oct. Uncommon. (*v.v.*)

1694*. **Coprinus Boudieri** Quél. Bull. Soc. Bot. Fr. XXIV, t. 5, fig. 5. Émile Boudier, the eminent French mycologist.

P. 1–2 cm., *pale tawny, disc fuscous, soon becoming blackish with a tawny disc*, ovoid, campanulate, 2–3 cm. high, *striate, then furrowed, sparsely covered with a delicate, white pubescence*; hairs hyaline, ventricose at base, 30–50 × 8–10(–18) μ, apex obtuse, 3–4 μ in diam. St. 3–8 cm. × 2–4 mm., *white*, slightly attenuated upwards, rigid, pruinose, pubescent. Gills *cream colour, then grey, at length violet-black*, adnate, linear, crowded; *margin white, micaceous*. Flesh *white, somewhat tawny at the*

fleshy disc. Spores fuscous, *mitriform,* 8–10 × 6·5–7·5 μ. Cystidia "30–36 × 15–30" Rick. Burnt earth and charcoal heaps in woods and pastures. July—Oct. Not uncommon. (*v.v.*)

1714*. **Marasmius gelidus** Quél. Boud. Icon. t. 74.
Gelidus, icy cold.

P. 1–3 cm., *very pale fawn, or flesh colour, disc darker,* membranaceous, campanulate, then expanded, slightly umbonate, often finally depressed; margin *rugosely striate,* hygrophanous, pruinose in dry weather. St. 5–7 cm. × 2–3 mm., *fawn colour tinged reddish,* equal, often incurved at the base and attached by a copious mycelium to the dead leaves, *covered with a delicate pubescence* which becomes longer and denser towards the base. Gills *paler than the pileus,* free, thin, fairly wide, *connected by veins.* Flesh *pallid, reddish in the stem.* Spores white, oblong, attenuated at one end, slightly incurved, 8–10 × 3·5–4 μ, contents granular. Smell none. Often fasciculate. Amongst leaves in woods. Nov.—Dec. Uncommon. (*v.v.*)

1806*. **Craterellus amethysteus** Rea. ἀμέθυστος, amethyst.

P. 1–2·5 cm., *tawny, paler at the margin,* fleshy membranaceous, convex, umbilicate, then somewhat infundibuliform, glabrous. St. 1–3 cm. × 3–4 mm., *tinged lilac,* gradually expanded into the pileus, often attenuated downwards, smooth. Hymenium *lilac,* wrinkled. Flesh *lilac* in the pileus and upper portion of the stem, *whitish* elsewhere, very thin except at the disc. Spores white, *globose,* 7–8 μ, *minutely echinulate.* Woods. Sept.—Oct. Rare. (*v.v.*)

1890*. **Boletus rhodoxanthus** (Krombh.) Kallenbach. (= *Boletus sanguineus rhodoxanthus* Krombh.; *Boletus purpureus* Fr. p.p.) Kallenb., Die Pilze Mitteleuropas, Band 1, Die Rohrlinge (Boletaceae), t. 2, fig. 3, t. 4, figs. 1–11.
ῥόδον, rose; ξανθός, yellow.

P. 5–20 cm., *pallid, yellowish white to pale brownish yellow, often suffused with rose colour, becoming darker when handled or weathered,* convex, then hemispherical, pulvinate, *delicately tomentose* under a lens, becoming somewhat viscid, smooth and ragged; margin *often rosy,* at first incurved, then irregular. St. 4–13 × 3–6·5 cm., *bright golden yellow, beautifully reticulated with blood red veins and dots, apex golden yellow, becoming reddish towards the greyish white, attenuated base, becoming bluish green by pressure,* ovato-ventricose, *then cylindric-clavate or subcylindrical,* arising from a *pale yellow mycelium.* Tubes *yellow, or greenish yellow, becoming bluish green* by handling or on section, somewhat free, short, then elongate; orifice of pores *lemon- or golden-yellow, then bright blood-red* with the exception of a marginal zone, and finally

darker and more olivaceous, becoming *bluish green when touched*, round, angular, minute. Flesh *lemon- or golden-yellow*, somewhat *reddish under the cuticle of the pileus and at the base of the stem, becoming bluish on exposure to the air, especially at the base of the tubes and apex of the stem, then paler and finally dirty yellow*, but remaining *bright golden-yellow* where eaten by slugs or otherwise injured, firm, *soon soft and spongy*. Spores olivaceous in the mass, yellow under the microscope, oblong elliptic, 9–11 × 4·5–5 μ ("elliptic fusiform, (9) 10–14(–16) × 4–5 μ" Kallenb.). 2–3–guttulate. Taste mild. Deciduous woods, especially beech and oak. July—Sept. Uncommon. (*v.v.*)

1943. **Polyporus amorphus** Fr.

Spores white, cylindrical, curved, 3–4 × 1 μ.

1949. **Polyporus lacteus** Fr.

Spores white, cylindrical, slightly curved, 3·5–4·5–7 × 1–1·5 μ, with a guttula at each end.

1978*. **Fomes pinicola** (Swartz) Fr. Gillet, Hymén. t. 464.
Pinus, pine; *colo*, I inhabit.

P. 10–50 cm., *white, becoming tawny or reddish, and finally black*, applanate, dimidiate, or hoof-shaped, *covered with a thin, resinous crust*; margin *whitish*, obtuse. Tubes *pale yellow*, 5–25 mm. long, harder than the flesh; orifice of pores *whitish, becoming yellowish*, minute, round. Flesh *pale yellow*, soft, firm. Spores white, obovate, 7–10 × 3·5–4 μ. Smell acid. Conifer trunks, more rarely on frondose trees. Jan.—Dec. Rare. (*v.v.*)

1997*. **Poria xantha** (Fr.) Lind. *ξανθή*, yellow.

P. 4–10 cm., *white, or pale sulphur-yellow*, effused, forming confluent patches, 2–5 mm. thick, immarginate. Pores *white, becoming pale sulphur-yellow*, round, or elongate, often oblique, thin, dissepiments fairly thick. Spores hyaline, allantoid, 4–6 × 1·5 μ. Hyphae flexuose, thick walled, 2–4 μ in diam., without clamp connections. On frondose and coniferous wood. Jan. Uncommon. (*v.v.*)

2058*. **Lenzites albida** Fr. Fr. Icon. t. 177, fig. 1.
Albida, whitish.

P. 4–6 cm., *milk white*, corky coriaceous, soft, dimidiate, sessile, becoming plane, sometimes effuso-reflexed, often imbricate, *zoneless, densely covered with a white, adpressed tomentum*, becoming silky with age and almost smooth. Gills *concolorous*, thin, dichotomous, often anastomosing and pore-like, edge entire. Flesh white, firm. Spores white, oblong, often slightly curved, 8–9 × 4–4·5 μ. On ash and birch trunks. Oct.—Feb. Rare. (*v.v.*)

2202*. **Odontia junquillea** Quél. Bull. Soc. Myc. Fr. XLII, t. 7, figs. 24–26. *Junquillea*, bright yellow.

R. 3–6 cm., *hyaline flesh colour, becoming cream-jonquil, isabelline, or tan colour*, effused, silky with hyaline hairs under a lens, then thickened, crustaceous and cracked; margin *white*, pruinose or subfibrillose. Spines *concolorous*, rigid, short, deformed, apex hispid. Flesh *concolorous*, waxy, then crustaceous, thick. Spores white, elliptical, attenuated at the base, 5–8–12 × 3·5–7·5 μ, 1-multi-guttulate; basidia 16–30–75 × 5–6–9 μ, with 2–4-sterigmata, 4–7 μ long. Cystidia very distinct at first, cylindrical, or narrowly clavate, 60–100 × 6–12 μ, *rugose*, then *adhering in fascicles, incrusted with large, split, oxalate crystals forming in their axis granular bands*, 150–200 × 9–24 μ. Hyphae thin walled, 2–6 μ in diam., at first very distinct, then collapsed, clamp connections frequent or rare. Deciduous and coniferous wood, shrubs and herbs. Jan.—Dec. Common. (*v.v.*)

2233*. **Hypochnus phylacteris** (Bull.) Rea. (= *Tomentella phylacteris* (Bull.) Bourd. & Galz.) Bull. t. 436, fig. 2.
φυλατήρ, a guard.

R. 2–10 cm., *grey, becoming brownish black*, broadly effused, membranaceous, adnate or separable, subiculum finally very thick, firm, densely felted; margin *whitish or concolorous*, villose or shortly fibrillose. Hymenium *greyish white, nut colour, smoky (very pale azure blue when fresh), becoming fuliginous, or remaining pale*, pruinosely mealy. Flesh *brownish bistre*, floccose, thick. Spores *brownish bistre*, with thin, short spines, globose, or oval, regular or sinuose, often obtusely mucronate, 7–9–15 × 6–8–10 μ; basidia, 25–60–75 × 6–10–16 μ, with 2–4-sterigmata, 6–8 μ long. Hyphae 3–9 μ in diam., *without clamp connections*, basal hyphae brownish bistre, firm, slightly thick walled, upper hyphae subhyaline, denser, frequently septate. Damp wood, bare soil, stumps and trunks of trees. Nov. Uncommon. (*v.v.*)

2238*. **Hypochnus tulasnelloideum** (von Hoehn. & Litsch.) Rea. (= *Corticium tulasnelloideum* von Hoehn. & Litsch. Beitr. zur Kennt. der Cort. in Sitzungsber. der k. Akad. d. Wissensch. Wien, Math-Nat. Kl. Bd. CXVII (1908), 1118, text-fig. 10, and Trans. Brit. Myc. Soc. VIII, 217, text-fig. 3.)
Tulasnella, the genus *Tulasnella*; εἶδος, like.

R. 1–3 cm., *mouse grey to bluish grey*, effused, very thin, closely adnate, *appearing like a pruinosity on the surface of the matrix*. Hymenium *concolorous*, smooth and continuous when best developed. Spores hyaline, very finely and closely echinulate, broadly elliptical to subglobose, 4·5 × 3 μ or 4 μ in diam.

("3·5–6 × 3–4·5 μ" von Hoehn & Litsch.); basidia clavate, 12–20 × 6–8 μ, with 2–4-sterigmata, 6–7 μ long. Hyphae distinguished with difficulty, "2·5 μ in diam. with clamp connections" Bourd. & Galz. Rotten, decorticated wood. Oct.—March. Rare.

Tomentellina von Hoehn & Litsch.

(*Tomentellina*, diminutive of *Tomentella*, a synonym of *Hypochnus*.)

Same characters as *Hypochnus* but *possessing cystidia*.

2239*. **Tomentellina ferruginosa** von Hoehn. & Litsch. Beitr. zur Kennt. der Cort. in Sitzungsber. der k. Akad. d. Wissensch. Wien, Math-Nat. Kl. Bd. cxv (1906), 1604, text-fig. 9. *Ferruginosa*, iron rust colour.

R. 5–10 cm., *rust-yellow to dark brown*, effused, floccose, soft, adnate, easily separable; margin generally *brighter in colour*, similar, or slightly radially fibrillose. Hymenium *concolorous*, discontinuous, becoming denser and granular, *velvety*. Spores yellow brown to brown, verrucose, warts short, blunt, subglobose or angularly globose, 6–9 μ, 1-guttulate; basidia clavate, 20–25 × 6–8 μ, with 4 straight or slightly bent, pointed sterigmata, 4–8 μ long. Cystidia *brown*, numerous, separate or in fascicles, narrowly cylindrical, slightly wider above, 120–200 × 5–8 μ, protruding up to 140 μ above the hymenium, obtuse, septate, thick walled. Hyphae bright yellow to yellow-brown, thin walled, 3–7 μ in diam., septate, without clamp connections; basal hyphae joined together in more or less thick, anastomosing cords. Rotten wood. Jan.—Dec. Not uncommon. (*v.v.*)

2253*. **Stereum insignitum** Quél. *Insignitum*, distinguished.

R. 3–6 cm., *bright tawny, or tawny rust colour, becoming brownish or grey, with concolorous or differently coloured zones*, reflexed, shell-shaped or fan-shaped, sometimes attenuated into a lateral, stem-like base, tomentose, becoming glabrous or satiny. Hymenium *pale, boxwood colour, ochraceous cream or leather colour*. Flesh *yellowish*, coriaceous, thin, intermediate layer bordered next to the tomentose surface by a golden zone and composed of flexuose, longitudinally arranged hyphae, which are either thick walled, 4–7 μ in diam., or thin walled, 3–4 μ in diam., and terminate in cystidia. Spores white, elliptical, or subcylindrical, slightly depressed on one side, 5–6 × 2·5–3 μ, basidia clavate, 20–35 × 3–5 μ, with 4-sterigmata. Dead beech branches and stumps. Jan.—Dec. Not uncommon. (*v.v.*)

Asterostromella von Hoehn. & Litsch.

(*ἀστήρ*, star; *στρῶμα*, a bed, a stroma.)

Receptacle membranaceous, crustaceous, or floccose, resupinate, effused. Hymenium smooth, farinose or pubescent. Spores white, oboval, oblong, fusiform, clavate or subglobose, smooth; basidia *scattered*, with 2–4-sterigmata, *greatly exceeding the hyaline or coloured, dichotomously branched, dendroid sterile mycelium or paraphyses*. Growing on wood, leaves, or on the ground.

2278*. **A. ochroleuca** Bourd. & Galz.

ὠχρός, pale; *λευκός*, white.

R. 1–4 cm., *ochraceous cream colour*, effused, incrusting, soft; margin *white*, fibrillose or pruinose. Hymenium *concolorous*, pelliculose, fragile. Spores hyaline, *subglobose*, very shortly apiculate at the base, 3–4 × 2·75–3 μ; basidia clavate, 15–23 × 4–4·5 μ, with 2–4 straight sterigmata, 4·5–6 μ long. Gloeocystidia sparse, fusiform, 18–36 × 6–7 μ, contents hyaline. Basal hyphae firm, very thin, ·5–1 μ in diam., branched; upper hyphae 2–3 μ in diam., branched, branches rigid, dichotomous, divaricate. Twigs, fallen branches, the ground and stones. Nov.—March. Uncommon. (*v.v.*)

2292*. **Corticium bisporum** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII (1923), text-fig. 1, p. 216. *Bis*, twice; *σπορά*, seed.

R. 2–6 cm., *white to cream colour*, effused, indeterminate, easily separable, very thin. Hymenium *concolorous*, forming a continuous pellicle above the loose cottony subiculum, often wrinkled or rather bullate when fresh but becoming smooth when dry. Spores hyaline, ovate, elliptical, or somewhat oblong, 8–11 × 4·5–6 μ, smooth; basidia arising from branched hyphae in a corymbose manner, clavate, 15–25 × 6–7·5 μ; sterigmata *constantly* 2, short 4–5 μ, divergent. Basal hyphae very loosely interwoven, septate, very rarely having clamp connections, 4–6 μ in diam. Rod-shaped crystals abundant in subhymenial tissue. Fallen branches. Uncommon.

2294*. **Corticium byssinum** (Karst.) Massee.

βύσσινος, made of fine linen.

R. 2–5 cm., *white, or cream colour*, irregularly effused, pelliculose, or submembranaceous, subadnate, fragile; margin byssoid or fibrillose. Hymenium *concolorous*, mealy. Subiculum arachnoid. Spores white, "*subglobose or ovoid*, 2·5–4 × 2–3 μ, often 1-guttulate, basidia 9–18 × 3–4·5 μ, with 2–4-sterigmata, 2–4 μ long. Hyphae rather rigid, regular, 2–3 μ in diam., *without clamp connections*, often granular or rough with rod-like crystals"

Bourd. & Galz. Fallen sticks, humus, etc. Sept.—April. Uncommon. (*v.v.*)

2296*. **Corticium diademiferum** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII, text-fig. 2, p. 217.
διάδημα, a band; *fero*, I bear.

R. *whitish to cream colour*, effused, very thin, margin indeterminate. Hymenium *concolorous*. Spores *subglobose*, 4–5 × 3–4 μ; basidia 15–21 × 5–6 μ, with 6–8-sterigmata. Hyphae thin walled, with clamp connections, 3–5 μ in diam. Bark of birch log. March. Rare.

2336*. **Peniophora miniata** (Berk.) Burt.*.
Miniata, coloured with red-lead.

R. 2–10 × 1–2·5 cm., *English red*, effused, tender; margin byssoid or fibrillose, often connected with blood red mycelial strands. Hymenium *concolorous, often drying pinkish buff to buff pink and cinnamon rufous*. Flesh 150–300 μ thick, *not coloured*, submembranaceous, arachnoid. Spores white, elliptical, 4–4·5 × 2–2·5 μ. Cystidia few, *not incrusted*, hair-like, protruding 20–30 × 3·5–4·5 μ above the hymenium. Hyphae loosely arranged, 3–6 μ in diam., not incrusted, rarely with clamp connections. Fallen limbs, usually of Conifers. July—Dec. Uncommon. England, Berkeley, British Fungi exsiccati, no. 251.

2391*. **Phaeocyphella episphaeria** (Quél.) Rea. (= *Calyptella episphaeria* (Mart.?) Quél.)
ἐπί, upon; *sphaeria*, the genus *Sphaeria*.

R. 1–2 mm., *white*, cup-shaped, sessile, externally *densely covered with long, flexuose, rough hairs*; hairs hyaline, often incurved at the apex, somewhat coloured towards the base, 40–70 × 3 μ. Hymenium *grey*, concave, even. Flesh *grey*, thin. Spores pale yellow-brown, broadly elliptical, obtuse, 8–9 × 5–5·5 μ; basidia 25–35 × 4–5 μ, with 4-sterigmata. Fallen branches attacked by *Sphaeria*. Nov.—April. Uncommon. (*v.v.*)

2411*. **Clavaria pallida** (Schaeff.) Bres. Bull. Soc. Myc. Fr. XLI (1925), Atlas, t. 3. *Pallida*, pale.

R. 6–8 cm. high, 2–4 cm. broad, *ochraceous cream, tinged with flesh colour upwards*; trunk 2–4 × 2–4 cm., *ochraceous cream, or pale coffee and milk colour, whitish at the base*, divided into numerous, erect, somewhat crowded, stout branches; branches *ochraceous cream, tinged with flesh colour*, dichotomous, sometimes slightly curved at the forks, cylindrical or compressed,

* The Thelephoraceae of North America, XIV (1926), Ann. Missouri Bot. Gard. XII (1925), *Peniophora*, 277.

rugose, especially longitudinally; *apices often tinged with lilac* when young, toothed, short, *obtuse*. Flesh *white*. Spores pale ochraceous in the mass, elliptic-oblong, obliquely apiculate at the base, 9–12 × 4·5–5 μ, 1–2-guttulate, becoming finally minutely verrucose; basidia clavate, 75–90 × 8–9 μ, with 2–4-sterigmata, 8–9 μ long. Smell faint. Taste sweet then bitter. Coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

2441*. **Clavaria truncata** Quél. (= *Craterellus pistillaris* (Schaeff.) Fr.) Bull. Soc. Myc. Fr. XXXIX, t. 3, figs. 1–4.
Truncata, maimed.

R. 6–15 cm. high, 2–9 cm. broad, *yellow, or ochraceous orange, becoming ochraceous or rufescent, turbinately clavate, apex truncate from the first*, then more or less hollowed out, rarely rounded or deformed; generally irregularly rugosely sulcate, pruinose, gradually attenuated downwards to the whitish base, rarely slightly rooting, arising from a network of white, cord-like mycelium. Flesh *whitish or ochraceous, turning slightly brownish violaceous on exposure to the air*, fibrillosely fleshy, firm, becoming spongy inside, cortex brittle. Spores pale ochraceous in the mass, hyaline, elliptic-oblong, with a sublateral apiculus, 9–13 × 5–6 μ, 1-multi-guttulate. Smell scarcely any. Taste *sweet*, sugary. Edible. Coniferous woods. Sept.—Oct. Uncommon. (*v.v.*)

2446*. **Clavaria luticola** (Lasch) Fr.
Lutum, mud; *colo*, I inhabit.

R. 5–20 mm. high, ·5–1 mm. thick, *yellowish, becoming brownish, apex often whitish*, simple, obtuse, attenuated downwards to the white villose base. Flesh somewhat fragile. Spores white, subglobose, 5–6 × 4–4·5 μ; basidia cylindrical, 8–12 × 4 μ, with 2 long sterigmata. Cystidia flask-shaped, 16–18 × 5–6 μ, apex obtuse, 3 μ in diam. Hyphae 2–3 μ in diam. Bare damp soil in woods. Sept. Rare. (*v.v.*)

***Black.

2452*. **Clavaria Greletii** Boud. Bull. Soc. Myc. Fr. XXXIII (1917), t. IV, fig. 4.
L'abbé L. J. Grélet, the eminent French mycologist.

Entirely black. R. 3–5 cm. high, 1–2 mm. thick, simple, elongate, slender, not fistulose. St. *fuliginous*, base *white*, short, glabrous. Flesh *fuliginous*. Spores white, globose, 7–8 μ, contents granular; basidia 17 × 4 μ, with 4-sterigmata. On the ground and old charcoal heaps. Oct.—Nov. Rare. (*v.v.*)

2458*. **Typhula candida** Fr. Fr. Icon. t. 200, fig. 3.
Candida, shining white.

R. 1–4 mm. high, *shining white*, club obovate, obtuse, rarely

subfusiform, sometimes bifid. St. *whitish, or reddish,* distinct, *glabrous,* or with a few scattered hairs which are gibbous at the base, *rough with oxalate granules.* Spores white, oblong-elliptic, attenuated and slightly bent at the base, 6–9 × 3–4 μ; basidia clavate, 15–33 × 4–6·5 μ, with 2–4-sterigmata. Hyphae thin walled, 3–15 μ in diam. Dead leaves, especially alder, ash, oak and willow. Oct.—Dec. Common. (*v.v.*)

Pistillina Quél.

(*Pistillina,* a little pestle.)

Receptacle minute, erect or pendant, somewhat firm, *pin-shaped,* stem cylindrical, smooth or villose, enlarged at the apex into a convex disc covered by the hymenium, which is sometimes ciliate at the margin. Trama filamentous, like *Pistillaria.* Spores white, oval, smooth; basidia with 2–4-sterigmata. Epiphytes, or growing on dead leaves.

2473*. **Pistillina hyalina** Quél. Quél. Ass. Fr. 1880, t. 8, fig. f2.
Hyalina, transparent.

R. 1–2 mm. high, *entirely white and diaphanous.* Disc 2–3 mm. wide, *hemispherical, then lens-shaped,* moist, then pruinose. St. very thin, dilated at the apex, base bulbous, puberulent with very narrow, thread-like hairs, –150 × 1–2 μ. Spores white, cylindrical, slightly curved, 7–9·5 × 3·5–4·5 μ; basidia 6–7 μ in diam., with 4-sterigmata, 6–7 μ long. Hyphae parallel, thin walled, interwoven at the base of the stem, expanding at the disc into a pseudoparenchyma composed of interwoven, closely compacted, thick walled, mucilaginous hyphae, containing numerous calcium oxalate crystals. Dead grasses and leaves. Feb. Uncommon. (*v.v.*)

2473**. **Pistillina Patouillardii** Quél. Pat. Tab. Analyt. Fung. t. 60, as *Sphaerula capitata* Pat.
N. Patouillard, the eminent French mycologist.

R. 1·5–2 mm. high, *entirely white.* Disc *globose,* ·3–·6 mm. in diam., *umbilicate beneath,* fragile, pruinose. St. diaphanous, very thin, equal, base abrupt, sparsely pubescent with simple or slightly branched, unicellular, capillary hyphae, –100 × 2–3 μ at base, apex 1–2 μ in diam. Spores white, elliptical, with an oblique basal apiculus, flattened on one side, 7·5–10 × 3·5–4 μ; basidia clavate, broadest just below the apex, 24–33 × 7·5–10 μ, with 2–4-sterigmata, straight or curved, 5–6 μ long. Hyphae parallel, thin walled, with numerous clamp connections, shorter and yellowish brown at the base of the stem, up to 17 μ in diam., becoming longer and narrower upwards and only 3·5–5 μ in diam. at the apex. Dead leaves and stems of *Phragmites* and *Rubus.* Aug.—Nov. Uncommon. (*v.v.*)

SEPTOBASIDIINEAE.

Saprophytes, with probasidia.

Septobasidiaceae.

Same characters as suborder.

Saccoblastia Moeller.

(σάκκος, a bag; βλαστός, shoot.)

Receptacle floccose, or gelatinous, effused. Basidia cylindrical, transversely septate, arising from a probasidium, which remains as a lateral, sac-like attachment at the base of the basidium; sterigmata lateral. Spores hyaline, smooth. Growing on wood.

2477*. **Saccoblastia sebacea** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII, text-fig. 4, p. 218. *Sebacea*, tallow.

R. 1–6 cm., *greyish*, effused, thin, fleshy, at first rather firm in texture, later becoming slimy-gelatinous. Hymenium *concolorous*, delicately pruinose and somewhat granulose under a lens when in good condition. Probasidium ovoid to oblong, 15–25 × 7–9 μ, pendulous, collapsing as the basidium matures and often breaking away in the preparation of sections. Spores hyaline, broadly elliptical, laterally apiculate, 7–10 × 4·5–7 μ, smooth, germinating immediately to produce secondary spores of similar form; basidia cylindrical, curved, 5–8 μ wide above, narrowing gradually to a more or less elongated pedicel below, with 2–3-transverse septa in the upper part; sterigmata lateral, conical, 8–10 × 2 μ. Hyphae frequently septate, without clamp connections, often constricted at the septa, 3–5 μ in diam., contents, as also those of the probasidium and young basidia, granular and with numerous oil drops. Old beech, birch and oak stumps. Oct.—April. Not uncommon. (*v.v.*)

2479*. **Platygloea Peniophorae** Bourd. & Galz. Trans. Brit. Myc. Soc. VIII, text-fig. 5, p. 219. *Peniophora*, the genus *Peniophora*.

R. *whitish to pale buff*, starting as small patches, then becoming effused; margin *white*, somewhat byssoid. Hymenium *concolorous*, pruinose under a lens, but interrupted here and there by masses of spores (conidia?) which are aggregated in semi-liquid globules. Spores hyaline, elliptical, with one side depressed, and with a pronounced lateral, oblique apiculus, 8–9 × 5–5·5 μ, germinating to form secondary spores of similar size and shape; basidia curved, transversely 2–3-septate, 5 μ wide; sterigmata filiform, flexuose, up to 40 μ ("90 μ and more"

Bourd. & Galz.) long. Growing over the hymenium of *Corticium praetermissum* (Karst.) Bres. and probably also of *Peniophora pubera* (Fr.) Sacc. March. Rare.

2479**. **Platygloea vestita** Bourd. & Galz. *Vestita*, clothed.

R. *dirty white, hyaline*, effused, slimy-gelatinous or somewhat waxy, somewhat thick, often evanescent when dry, *clothed with white, loosely interwoven threads*. Hymenium *concolorous*. Spores hyaline, oblong-elliptical or subcylindrical, obliquely acute at the base and depressed on one side, 18–25 × 6–7 μ ("15–21–30 × 5–7·5–9 μ" Bourd. & Galz.); basidia obovate, then cylindric-clavate, transversely 1–3-septate, 40–50 × 8–10 μ; sterigmata conical, then slender, up to 20 μ long. Mycelial hyphae, 8–10 μ in diam., thin walled, enodulose, giving rise to *erect*, flexuose, *torulose* branches, 60–100 × 6–10 μ, protruding to 40–50 μ above the hymenium. Rotten beech wood. Jan.—Dec. Uncommon. (*v.v.*)

2481. **Auricularia auricula-Judae** (Linn.) Schroet. var. **lactea** Quél. *Lactea*, milk-white.

Differs from the type in the *whitish straw-coloured receptacle, and snow-white hymenium*. Old elders. Nov.—May. Uncommon. (*v.v.*)

2497*. **Tremella glacialis** Bourd. & Galz. *Glacialis*, icy.

R. ·4–1 mm., *limpid*, shining when dry, not melting away, soon reticulately or areolately touching, not truly confluent. Flesh waxy, subcartilaginous. Spores hyaline, oblong, acute at the base, often laterally subdepressed, 5–6–8 × 3·5 μ, germinating on the side; basidia ovoid, 7–10 × 5–8 μ, 2(–4) subulate sterigmata, 10–20 × 1–1·5 μ. Hyphae scarcely distinct, 1–2 μ in diam. Moist rotten wood. Jan.—Dec. Uncommon.

2522*. **Tulasnella violacea** (Johan Olsen) Juel. Trans. Brit. Myc. Soc. VIII, text-fig. 6, p. 220. *Violacea*, violet.

R. 1–6 cm., *deep violet, drying to pale lilac*, effused, very thin. Hymenium *concolorous*. Spores hyaline, *subfusiform, curved*, 8–10 × 6–7 μ ("15 × 8 μ" Juel.); basidia subglobose to oblong, 12 × 8–11 μ; sterigmata 8–10 × 6–7 μ. Basal hyphae septate, without clamp connections, 4–5 μ in diam. Bark of old birch log. Jan.—March. Rare. (*v.v.*)

2522**. **Tulasnella allantospora** Wakef. & Pears. Trans. Brit. Myc. Soc. VIII, text-fig. 7, p. 220.
ἀλλᾶς, sausage; σπορά, seed.

R. *hyaline, or with a very faint pinkish or lilac tinge*, effused, waxy, very thin. *Hymenium concolorous*. Spores hyaline, *cylin-*

drical, curved, attenuated at both ends, 9–10 × 3–4 μ; basidia obovate, 7–10 × 6 μ; sterigmata elliptical, 7–9 × 5 μ. Basal hyphae septate, 2–3 μ in diam., no clamp connections. Decorticated coniferous wood. Feb.—April. Uncommon. (*v.v.*)

2523*. **Tulasnella microspora** Wakef. & Pears. Trans. Brit. Myc. Soc. VIII, text-fig. 8, p. 220.

μικρός, small; *σπορά*, seed.

R. *pale lilac*, effused, very thin, pulverulent. Spores hyaline, *ovate*, 5·5–6 × 3–3·5 μ; basidia obovate or elliptical, 7–10 × 5–6 μ; sterigmata elliptical, 2·5–3·5 × 2–3 μ. Basal hyphae branched, septate, 2–3 μ in diam., no clamp connections Rotten coniferous wood. March—April. Rare.

Subgen. **Gloeotulasnella** von Hoehn. & Litsch.

(*γλοιός*, sticky; *Tulasnella*, the genus *Tulasnella*.)

Differs from *Tulasnella* in possessing gloeocystidia.

2524*. **Tulasnella (Gloeotulas.) cystidiophora** von Hoehn. & Litsch. Beitr. zur Kennt. der Cort. in Sitzungsber. der k. Akad. d. Wissensch. Wien, Math-Nat. Kl. Bd. cxv (1906), 1557, 1558, 10, 11, text-fig. 1.

Cystidium, cystidium; *φέρω*, I bear.

R. 1–10 cm., *bluish grey, becoming black when dry*, irregularly effused, adnate, thin. Hymenium *concolorous*, loose, not continuous. Flesh gelatinous or waxy, finally collapsing when dry into a crust-like film. Spores white, oval, oblong or globose, 10–13 × 8–11 μ, with 4 oval sterigmata. Gloeocystidia *very variable in size and shape*, often very flexuose, 10–30 × 7–11 μ, filled with little oil globules. Hyphae hyaline, smooth, septate, 2–4 μ in diam., with a few, sparse clamp connections. Poplar bark. Nov.—Jan. Uncommon. (*v.v.*)

THE BRITISH MYCOLOGICAL SOCIETY was founded in 1896 for "the study of Mycology in all its branches." In its earlier years the Society was carried on much as had been the mycological section of the Woolhope Club, but differed mainly in holding the annual meeting and foray in various parts of the country and in having a journal wholly devoted to Mycology In the year 1909 an informal spring foray was added to the Society's activities. Since 1921 a much fuller programme has been carried out; the number of forays has been increased while indoor meetings provide for the report and discussion of the results of investigations. Mycologists visiting England are cordially invited to attend any of the meetings of the Society. The programme for the year is issued in January and may be obtained from any of the officers.

The Transactions of the Society appeared annually until 1919 when two numbers were issued; they are now published quarterly. The Transactions deal with every branch of Mycology, and a volume at present contains at least 240 pages with numerous plates and text-figures. Owing to the increase in membership of the Society and the sales of the Transactions, arrangements were made in 1922 for the Cambridge University Press to take over the publication. The annual subscription for Membership of the Society is £1, payable in advance and is due on January 1st of each year. Members are entitled to receive the Transactions of the Society during the year covered by their subscription. For the subscription price to non-members see overleaf.

Many of the earlier numbers of the Transactions are now out of print, but occasionally copies of these come to hand. Information as to parts available can be obtained on application to the General Secretary.

Papers submitted for publication should be in a condition suitable for press. The Editors are willing to give advice and assistance in the preparation of MSS. Illustrations should be kept down to a minimum. Members are asked to help the Editors to bring the Transactions out regularly. Fifty reprints are provided free of charge: additional reprints may be obtained through the Cambridge University Press.

Attention of members is called to the advisability of sending cultures of fungi to the NATIONAL COLLECTION OF TYPE CULTURES, Lister Institute, Chelsea Gardens, S.W. 7, for preservation and distribution.

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(*Recognosce notum, ignotum inspice*)

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RECENT LICHEN LITERATURE.

By A. Lorrain Smith, F.L.S.

INTRODUCTION.

THE scope of the present paper has been enlarged to include, as far as possible, all types of publications dealing with lichens. Both in the Handbook *Lichens** and in two subsequent papers issued in these *Transactions*, the systematic papers consisting mainly of lichen lists had been omitted. It is owing to special request that all publications dealing with lichen study, and omitted from my previous papers, dating back to 1920 or, in some few cases, to an earlier date, have now been inserted in the list of literature.

Several important books have appeared recently. One of the most notable, Tobler's *Biologie der Flechten*. After an introduction the subject matter, divided into chapters, deals with (1) Development and Growth, (2) Physiology, (3) Ecology and Adaptation, and (4) Symbiosis. Tobler is a convinced believer in the theory of symbiosis but he discusses and gives due prominence to the different views held by lichenologists; he also treats of the phylogeny of lichens and their reproduction processes. A bibliography giving notes on the works cited is a welcome feature of the book which is a very valuable addition to lichen literature.

Lichenologists of all nationalities are immeasurably indebted to Dr A. Zahlbruckner for his *Catalogus Lichenum Universalis*. He has already completed the third volume, and the fourth is in progress. Descriptions of genera and species are not supplied, but the authoritative systematy which includes a full account of nomenclature, along with habitat and localities of the plants, must give a great stimulus to systematic lichenology.

In addition to the above important work Zahlbruckner has issued a new edition of *Lichenes* (1926) in Engler-Prantl's *Pflanzenfamilien*. On the first page is recorded the lamented death of Dr M. Fünfstück who compiled the "Introduction." That portion of *Lichenes* had, however, been brought by him up to date as regards new works published since the printing of the first edition (1903–7). In the systematic portion Zahlbruckner has included much new material and some re-arrangement of families: the gelatinous lichens have now been inserted before the great groups of Lecideales and Lecanorales. The thanks of all lichen students are due to the renowned author for this masterly work.

* Cambridge University Press, 1921.

Another work of importance is Professor Migula's contribution on Lichens to the *Flora of Germany, Austria and Switzerland*, a work which was much needed for Central Europe. After a comprehensive introduction on general lichenology, there follows the systematic portion; and here we would enter a protest against the spelling of the genus *Teloschistes* thus named by Norman, but almost invariably as here, rendered as *Theloschistes*. The work is enriched by many coloured plates. Migula tends to the view that the relation of hyphae to gonidia in the thallus is a mild type of parasitism. The Flora is not yet completed.

There has also appeared a second edition of Part II of the Monograph of the British Lichens by myself. The new volume contains a number of necessary corrections, and additions. One genus has been added to the British list: *Clathroporina*, with a new species *C. calcarea* which was found and determined by Dr W. Watson. A number of species new to the British flora, some of them new to science, are included. Generous helpers in various districts have considerably widened our knowledge of lichen distribution in Great Britain and Ireland.

THE LICHEN PLANT.

Lichen Hyphae. Artificial cultures of lichen hyphae to illustrate lichen development have been carried out by Ch. Killian and R. G. Werner (1924). They found that spores of *Cladonia squamosa* germinated freely and in six weeks minute hyphal colonies had been formed. Sections of these were made, and a differentiation of tissue was already visible—a loose plectenchyma at the centre, with hyphal filaments at the periphery; a month later a small dome (about 1 mm.) was observed which in five months had increased to a height of 5·3 mm. The dome itself was unchanged in form, growth being intercalary in the basal region; but three tissues were then distinguishable—a medulla, a cortical tissue and between these two a region of loose hyphae in the position of the gonidial zone.

In a note published later (1925), Killian records results of the hyphal culture of *Xanthoria parietina*. There was a healthy growth and the body of hyphae was yellow. Killian draws the conclusion that lichen-fungi are able to develop without the alga. The production of the yellow colour can hardly be due to the presence of parietin as that is very closely associated with the presence of gonidia as proved by Tobler*. A more detailed account of *Xanthoria* culture is given by Werner (1926).

* See *Lichens*, p. 50.

The hyphae, developed from the spore, reached in ten months a size of 1·4 cm. in diameter, and 1 cm. in height. That is a rather abnormal development for *Xanthoria*, as the lichen lobes are in nature (when associated with gonidia) extremely thin as compared with their expansion. Werner noted the different tissue systems. A loose medulla, with rhizinose hyphae at the base, upwards a still looser tissue where the gonidia would normally be found and on the upper side a cortical layer with aerial filaments as described by Tobler* who also had found that the hyphae were brownish in colour.

Gonidia. An account of the distribution of the alga, *Trentepohlia*, by Paul van Oye (1923) has a direct bearing on the distribution of Graphidaceae in which family it is the almost constant gonidium. Both the alga and the lichen are abundant on trees in the tropics. Van Oye found that the alga grew in well-lighted positions, the presence of moisture being only of secondary importance, an observation that applies also to lichens which are mostly sun plants. The alga is protected from a too strong effect of insolation by the presence of haematochrome in the cells; it occurs at an elevation of 200 m. to 600 m above sea-level.

A curious account of the alga *Mycoidea parasitica* in Japan has been given by Molisch (1925). This alga is the gonidial symbiont of the lichen *Strigula* which is extremely abundant on leaves in India and other tropical lands. The alga itself is very common in Japan, but not the lichen. Whether this was due to the absence of the *Strigula* fungus or to the nature of the alga in Japan, Molisch could not decide.

The genus *Moriola* (Pyrenocarpaceae) was first described by Norman (*Bot. Not.* 1872, p. 113). The species grow on soil or bark and, so far, have been found only in Scandinavia. Recently Bachmann (1926) by careful study has cleared up much of the obscurity that has always surrounded the genus. In *Moriola pseudomyces* he found the main feature—the goniocysts—as had already been described, and compares them with the soredia of other lichens: they consist of a core of about a hundred algal cells of Cyanophyceae, possibly of more than one type. The hyphae are brown and occur at first in strands, then, as the goniocysts increase, the hyphae develop as permeating or as cortical tissues, the whole structure spreading until it is several times as broad as high. The mature cortex is composed of a layer of cells the outer walls of which are brown. The algae develop vigorously at first, then arises some parasitism of the hyphae on the algae, though Bachmann insists on the essentially symbiotic character of the association.

* See *Lichens*, p. 50.

The gonidium of our common lichens has been the subject of much study both as to its development and its systematic position. A paper by Puymaly (1924) in which is given a satisfying and conclusive account of this alga marks an important advance in exact knowledge. He has verified Treboux's description of it as a body with a large chromatophore and central pyrenoid; he finds, as did Paulson and Hastings*, that the contents round off into daughter-gonidia (aplanospores or autospores); he found this alga not only in lichens, but also as a free-living plant in the open, and as it differs from both *Cystococcus* and *Chlorococcum*, in which genera it has been classified, Puymaly has placed it in a new genus *Trebouxia*†.

M. and Madame Moreau (1925) concur in the conclusions of Puymaly. They have found the alga frequently on trees, and in many different lichens; but while asserting that the alga develops exactly as described, they figure a first transverse division before the contents round off into spores. This is a considerable variation from the direct formation of daughter gonidia as described by Treboux, Puymaly and Paulson, who found that no such division took place; nor did zoospores occur.

The gonidia of other types of lichens were also noted by the Moreaus; in *Solorina saccata* they found the alga was *Coccomyxa* as was previously determined by Chodat. In *Peltidea* they found *Stichoccoccus*—the minute form usually associated with hymenial gonidia (Zahlbruckner (1926) gives *Dactylococcus* as the alga of *Peltidea*). In all their work the writers detected no penetration of gonidia by the lichen hyphae, nor did they see the "pushing" hyphae described by Nienburg.

A careful description of hymenial gonidia in *Staurothele* adds to the value of Zschacke's work on Verrucariaceae (1924).

Morphology.

Aeration organs. An account of Norwegian species of *Nephroma* by Ove Høeg (1922) includes species with bright green gonidia (*Nephroma*) as well as with blue-green (*Nephromium*). He has paid special attention to the white spots or "pseudocyphellae" present on the lower cortex of *Nephromium resupinatum*. He found them chiefly in the neighbourhood of the apothecia which in this genus develop on the under surface. He considers them to be aeration organs but differing in origin from cyphellae or pseudocyphellae. They arise as papillae with a loose cortex and when that is broken off, there is left a hollow white spot resembling the cyphellae of *Sticta*. He finds thus three types of definite aeration organs: cyphellae as in *Sticta*

* *Lichens*, p. 56. † See also West and Fritsch, *British Fresh water Algae*, 1927.

sylvatica; pseudocyphellae in *Sticta crocata* and papillae in *Nephromium resupinatum*.

A description by Darbishire (1926) of the minute open pores on the under surface of the isidia of *Peltigera praetextata* adds further to our knowledge of lichen adaptations for securing gaseous exchange.

Du Rietz (1925) has described pseudocyphellae in *Parmelia Kernstockii*, yet another instance of the occurrence of aeration organs. Du Rietz refers also the white dots of *Parmelia cetrarioides* to pseudo-cyphellae.

Soredia. Du Rietz (1924) has gone somewhat deeply into the distribution and form of soredia and isidia. There is a tendency to excessive elaboration. He sets forth two types of soredia:

A. Diffuse soredia—when the whole or larger part of the thallus or cortex is dissolved into a continuous layer of soredia.

B. Limited soredia (soralia of Darbishire)—which are superficial or marginal. In this latter type he delimits soredia *punctiformia*, as in *Parmelia revoluta*, etc.; *maculiformia* as in *Pertusaria globulifera*; *rimiformia* as in *Parmelia sulcata*; and *maniciformia* (cuff soredia) which form a sorediate edge round any depression or hole. He also gives as a separate group those that form a border round the margin of the thallus.

In a recent study of soredia in *Peltigera erumpens* and *P. scutata* Darbishire (1927) has described the endogenous origin of these bodies. They arise owing to the activity of the meristematic tissue of the gonidial layer, but which element—gonidium or hypha—gives the stimulus to soredial formation, it is impossible as yet to say: there is undoubtedly close cooperation between the two symbionts; the hyphae push their way up through the cortex without causing any wound.

Darbishire raises anew the question of the connection—if any—between isidia and soredia and quotes Bitter in favour of his own view that they are distinct and separate products of the thallus; but in his account of *Parmelia farinacea* Bitter (*Hedwigia*, XL, p. 175, 1901) describes the isidia of the thallus as passing over to soredia, "die feinen isidiosen Sprossungen die sich endlich in Soredien umwandeln"; and again (p. 177), he notes, "*Parmelia farinacea* scheint mir ein gutes Beispiel dafür zu sein dass in manchen Fällen eine scharfe Grenze zwischen Isidien- und Soredien-produktion nicht besteht." Bitter holds, however, that in general they are distinct and specific. Rosendahl also in his work on the brown Parmeliae found sorediose isidia to be characteristic of *Parmelia verruculifera*.

Isidia. These are treated by Du Rietz (1924) in the same

detailed fashion as the soredia: they are divided into isidia *verruciformia* which occur as small outgrowths or warts; *cylindrica* as in *Pertusaria corallina*; *claviformia* as clavate hollow structures which may develop into squamules as in *Parmelia exasperatula*; *squamiformia* as in *Peltigera praetextata* and *coralliformia*—branching isidia as in *Umbilicaria pustulata*.

These divisions and subdivisions, both of soredia and isidia, though almost too detailed, do draw attention to the variety in lichen structures. Du Rietz considers both soredia and isidia in their different forms to be constant and specific, and not merely growth phenomena due to shade or excessive moisture. Parallel species, the one type bearing isidia or soredia, the other without these structures, are well recognised and have a definite distribution. The main function of soredia and isidia he considers to be that of propagation, though in isidia the extension of the gonidia-containing tissue adds to the amount of photosynthesis.

Darbishire (1926) deals with the isidia of *Peltigera praetextata*; but an account of the general development of the thallus is also given: marginal growth is provided for by the hyphae immediately below the gonidial zone—the meristematic tissue—which grow out horizontally and some of the cells form the tomentum by which the young margin is protected. The isidia are small outgrowths from the upper surface, usually the margin, of the mature thallus. They are formed from the gonidial hyphae which push up through the cortex; or isidia may arise where a crack in the thallus has taken place. The tissue layers are the same as those of the thallus; the under cortex is only one cell thick and is interrupted by occasional openings or pores of regular oval shape which evidently function as air-pores and are important for photosynthesis. These leaf-like isidia—the isidia *squamiformia* of Du Rietz—function rather as assimilative than as reproductive bodies; they enlarge considerably the photosynthetic surface. This view is reaffirmed in Darbishire's further paper (1927) but he seems to limit their function entirely to assimilation, whereas they are generally somewhat easily detached and are thus well fitted to reproduce the parent lichen.

Reproduction.

Not much work has been done on this difficult subject, but M. and Mme Moreau (1925) have contributed a study of apothecial development in *Parmelia acetabulum*, *Physcia* (*Xanthoria*) *parietina* and *Anaptychia ciliaris*, species which in the past have been favourite objects of similar research by workers such as Baur, Darbishire and others. It is with considerable interest that we turn to the results and conclusions arrived at which prove to be both new and unexpected. The most astonishing is

the discovery of clamp connections such as occur in the hyphae of Basidiomycetes, and not hitherto recorded for any Ascomycete. The writers claim that their occurrence establishes a relationship between the two great groups of fungi—Basidiomycetes and Ascomycetes—thus pointing to a common origin; but, accustomed as we are to the clearly defined clamps in Basidiomycetes, we find those ascomycetous "clamps" somewhat ill-formed and, as yet, not very convincing

Baur* had described a somewhat unusual development of the apothecial tissues in *Parmelia acetabulum.* The Moreaus find, as he did, that several carpogonia lying near the surface take part in the formation of the ascogonium; trichogynes are produced, but are evidently functionless. A wall of plectenchyma surrounds the young ascogonial tissue, which is formed of uninucleate hyphae rich in contents, and is traversed in an upward direction by sterile hyphae destined to become paraphyses. At a later stage, the ascogonial tissue is formed as a layer below the paraphyses and the hyphae are now binucleate. At this stage the clamp connections appear. This sequence of tissues is evidently the same as described by Baur though perhaps less clearly indicated. Finally the ascogenous hyphae penetrate the thalamium, a terminal septum cuts off the ascus, and details of further development follow.

In *Xanthoria parietina* they found that the ascogonial cells became plurinucleate, but the origin of this condition as also of the binucleate cells of *Parmelia acetabulum* was not traced. The authors base certain conclusions as to the origin of Ascomycetes on the varying types of ascogonial cells. Finally they draw attention to two subjects that require elucidation: (1) the origin and function of the trichogyne, and (2) the appearance of the binucleate cells.

In a discussion on reproduction, Zahlbruckner (1924) came to the conclusion that reproduction by sexual organs exists in the more primitive genera of Phycolichenes, but has died out in more highly developed forms such as *Peltigera,* and he adds that, probably, the same course of development occurs also in Archilichenes.

In the study of Norwegian Nephromae Ove Høeg (1922) made observations on the position of the pycnidia: they were marginal on the thallus of *Nephroma arcticum, N. laevigatum* and *N. resupinatum,* and on the under surface in *N. expallidum*; the latter species has a thin, rather weak cortex.

An interesting research on spore production in *Solorina crocata* has been successfully carried out by A. Hilitzer of Prague (1926). Spore discharge has often been seen and

* *Lichens,* p. 169.

described in Discomycetes: the phenomenon is more obscure in the long-lived apothecia of Discolichenes. The apothecium of *Solorina saccata* develops beneath the cortical layer of the thallus and the growth and expansion of the primordium push down the gonidial layer; at a more advanced stage a dense layer termed by Hilitzer as a lower cortical layer is formed below and provides a firm unyielding base to the hymenium. In time the emergence of the apothecium ruptures the overlying thallus, shreds of which remain on the outer margin of the disc. Some of the asci and spores reach maturity at the same time. Ejaculation results after wetting: a moist atmosphere is insufficient; rain or (in laboratory conditions) drops of water are essential to ensure spore discharge by thoroughly wetting the hymenial tissues. The pressure induced by the swelling of the paraphyses causes the rupture of the asci and the ejaculation of the spores. The specimens were kept in the laboratory, and statistics have been compiled by Hilitzer as to the number of asci and spores, and the continuation of spore production: in *Solorina* the apothecium retains fertility, *i.e.* the continued formation of asci and spores for two to four years.

Physiology.

Lichen Starch. There has been some discussion on the occurrence of starch in the lichen plant. That starch is produced by photosynthesis in gonidia as in other green plants is a well-known phenomenon, and can scarcely be regarded as a product of symbiosis. In a previous paper Mameli (1920) stated she had found starch grains not only inside the alga but also outside close to the gonidia. Tobler (1923) has taken up the question and found at certain periods (June to August and February to May) granules smaller than those described by Mameli on the outside of the gonidia—the lichens examined were from both shady and sunny situations. In lichens collected in October he found a greater abundance of starch within the green cells and the outside granules larger than those previously seen. He noted further that the granules became fewer and had almost disappeared during the darker months of the year. Fungal hyphae possess the capacity of absorbing carbohydrates and this record of the exchange of nutritive substances between alga and fungus gives an added support to the theory of symbiosis.

Lichenin. The problem of symbiosis has led to a research by R. and L. Chodat (1924) on the possibility of the gonidia being able to utilise the lichenin of the lichen hyphae. They experimented with gonidia from species of *Cladonia* which they grew on agar with or without an addition of glucose and lichenin.

Another series was tested on agar with saccharose and with maltose.

Lichenin added to any of the media had no effect on the cultures. Glucose was the most favourable to the growth of gonidia as well as to free algae: it alone doubled production. The authors gathered from these results that lichenin had not been available because the gonidia did not secrete the ferment that would have broken up and prepared the substance. It has been proved that when lichenin and maltose are hydrolysed by enzymes they form glucose, but evidently no glucose was formed in the cultures.

Isolichenin. From Giegenspeck (1924) we have a study of the blue reaction of the asci of lichens on the application of iodine, a reaction at one time considered to be one of the distinctions between lichens and fungi, though that has been long disproved. Czapek had concluded that the staining substance was some carbohydrate of the nature of galactose*, and Moreau gave to it the term amyloid. Giegenspeck has now found that isolichenin is present in the asci of *Xanthoria parietina*, *Cladonia coccifera* and *Ramalina fraxinea* along with small quantities of methylpentose and glucose. Isolichenin, usnein and evernin, he finds, have an affinity for moisture and must be of service in the absorption of water.

In the ascus, isolichenin was proved to be of value as a reserve material: he found it in larger or smaller quantities in the hymenium of *Cladonia furcata*, *Cetraria islandica*, *Usnea dasypoga* and *Xanthoria parietina*, and in great abundance in the soredia of *Lecanora tartarea*. In the asci of many fungi isolichenin is present, in others it is replaced by glycogen. In some lichens, *e.g. Baeomyces* sp., and *Graphis scripta* it was absent from the hymenium, but was present in the spore septa. The blue coloration when present fills the whole of the young asci but gradually disappears with the maturing of the spores. Though some lichens such as *Solorina* contain both isolichenin and glycogen, Giegenspeck found that where there was much of the one substance there was little or none of the other. An account of amyloid hyphae, *i.e.* lichen hyphae that give a blue reaction with iodine has been published by Bachmann (1926) who has suggested that the blue colouring substance of the outer hyphal walls may be identical with the isolichenin found by Giegenspeck in the asci. These hyphae occur in several species of *Lecidia* and also in *Rhizocarpon distinctum*: they are present in the cortex, gonidial zone and medulla, but the colour reaction is absent from the hyphae encircling the gonidia and from the outer and inner layers of the cortex. Bachmann

* See *Lichens*, p. 212.

considers that hyphae in these positions have been altered in chemical properties owing to special function. The yellow or brown cells that envelope the fruiting bodies are also without the blue reaction.

Colour Difference in Lichen Thalli. This subject was commented on by E. and F. Bachmann in their account of Litau lichens (1920). In full insolation many greyish lichens are often brown in tone: the brown swards were found in Rugen to be due to the presence of *Cetraria aculeata*, *C. stuppea* and *Cladonia furcata* f. *palamaea*; much the same lichens gave brown coloration on the Litau heaths while *Parmelia olivacea* formed brown patches on the erratic boulders. Colour differences in the same species are in no lichen so obvious as in *Xanthoria parietina* as indicated by the names given to the supposed varieties and forms of the species: *chlorina*, *albicans*, *virescens*, etc. The bright yellow colour so distinctive of the normal plant is due to the presence of the crystals of the lichen-acid, parietin, and the alteration of colour is caused by the varying amount of the acid deposited on the hyphae. Tobler (1925) has examined anatomically a large series of specimens to determine the origin and nature of the colour changes. He has concluded from his observation that the amount of parietin is conditioned by the amount of carbohydrate or starch provided by the symbiotic partner, the gonidium. One might rather consider parietin formation a symptom of all-round vitality. In favourable conditions of moisture and sunlight, he finds, gonidia are abundant and photosynthesis active, thereby resulting in a high production of starch. The hyphae also in such a favourable condition of nutrition form an excess of parietin as shown in the deep yellow colour of the thallus. Thalli growing in the sunlight as compared with those in the shade show a denser deposit of parietin, thicker cortex and more numerous densely packed gonidia and therefore more starch formation.

Räsänen (1927) found that nitrophilous—or as he prefers to call them ammoniophilous—lichens vary in colour according to the ammonia present on the substratum. If little is present *Xanthoria lychnea*, one of the most nitrophilous species, is red-yellow in colour (f. *aureola*); if a large quantity, then the colour is greenish-yellow (f. *chlorina*). He allows that light and shade also affect colour.

A paper on lichen colour substances must be noted here though it dates back to 1917. In it Ryan and O'Riordan deal with the chemistry of the acids contained in the familiar lichens *Parmelia saxatilis* and *Ramalina scopulorum*. Much of the matter is concerned with methods of extraction (chiefly with acetone) and with the exact chemical formulae. Attention is

specially directed to the acid which gives the colour reaction, light yellow, then rust red; this they found in *Parmelia saxatilis*, and decided that it was salazinic acid. Zopf (1907) had pronounced the substance to be saxatilic acid, an isomer of salazinic acid, and gave the reasons for so regarding it.

Ryan and O'Riordan found that the scopuloric acid of *Ramalina scopulorum* showed also a close affinity to salazinic acid. From *Xanthoria parietina* they extracted physcione which on treatment yielded crystals, as yellow needles. When wool was boiled with this substance it acquired a dull orange-yellow colour, but with the addition of alumina as a mordant it was dyed a bright orange-yellow shade.

Migula (1924) in the preface to his *Lichen Flora* speaks of the action of lichen acids as not being confined to rock substrata; he suggests that it is by acids that the middle lamellae of the "host" cells are dissolved in corticolous species.

K. Goebel (1926) has suggested that lichen acids may prevent a too great absorption of water. In certain species the aerial hyphae are not easily moistened, but if the acids are removed by alcohol or ether, water is at once absorbed by the thallus.

Albo (1926) in a discussion of Sicilian lichens lays particular stress on the importance of oxalic acid to the plants. It is deposited in granules and crystals in the hyphae and lowers the concentration of nutritive solutions which according to him allows the inflow of new salts. It also lowers the freezing point of the lichen sap, thus enabling the lichen to exist in extreme cold.

Acidity or Alkalinity of the Substratum. Great attention has been given especially by ecologists to the *p*H values of soil, water, etc., as an influence in the growth of vegetation. Trümpener (1926) has attacked the problem of lichen distribution with regard to hydrogen ion concentration by testing the substratum—saxicolous or corticolous. He took a thin layer of the stone or bark, etc., soaked it for some hours in a definite amount of water and then tested it by the usual methods. He found on trees that the base of the trunk was more alkaline than the higher stem and branches and that ammoniophilous lichens congregated there. Might it be suggested that at the base there would be accumulated the washing down of bird's excreta which would account for the greater alkalinity? Ammonia he found was the source of the nitrogen required by lichens, and not nitrates or nitrites. He declares that the heat and dryness of town areas are as potent in banishing lichens as the presence of soot or gases in the atmosphere. This could not however apply to the large districts in the neighbourhood of our industrial towns—great moorlands

almost emptied of lichen vegetation. The subject of nitrophilous species is fully discussed.

Water Conduction. A preliminary paper on water absorption and storage as observed in Java lichens has been issued by K. Goebel (1926). Non-corticate lichens such as *Coenogonium* and *Dictyonema* spp. absorb water like a sponge. Those with projecting hyphal hairs or cilia also obtain water easily as these act as capillary agents. It is the smooth closely corticated forms that present the chief problem; but Goebel finds that the hyphae of these species with their swollen cell-walls readily imbibe water and that water travels from cell to cell. Chondroid tissues are, therefore, of use not only as strengthening tissues but also for water conduction. Gelatinous substances without structure as in *Collema* very readily imbibe water.

Bionomics.

An instructive paper by E. J. Fry (1926) gives further illustrations of the mechanical action of lichens on the substratum. On this occasion she deals with corticolous, crustaceous species. The hyphae penetrate the bark through cracks or other openings; in no case did she observe any penetration of the bark cells. Species of Graphideae and Lecanorae were examined and she found that under the thalline areolae, but especially under the reproductive bodies, there was an arched hollow formed, caused by the swelling of the gelatinous hyphae when moist. This dragging up of the periderm tended to loosen and disintegrate the host tissues. Experiments were made by planting apothecia on rubber and then moistening them: a hollow was at once formed under these bodies. It was observed that no arching took place under a loose powdery thallus: in such a case there was not enough thalline cohesion, no definite tissues being present. The author has thus proved that any disintegrating action of corticolous lichens on their substratum is mechanical and not chemical, being caused by the alternating expansion and contraction of the lichen tissues due to their absorption or loss of water.

A somewhat different explanation is given by Räsänen (1927, pp. 83–4). He considers that these corticolous species are not merely epiphytes: they are saprophytes (*corticis aprophyta*) as proved by the disintegrated and destroyed periderm cells. No one as yet has, however, found that the cells are entered by the lichen.

McWhorter had used the story of plant succession (lichens growing over mosses) as an argument to prove that lichens were parasites on the mosses. More recently Jennings (1923) has added more instances of the struggle as parasitic between the

two classes of plants; but we would point out that it is the mechanical smothering effect of the marauding plants that kills off the mosses: a very different conception to that of parasitism. One of the few cases of lichen parasitism is recorded by Malme from Brazil*.

Classification and Distribution.

Systematy. Critical discussions on this subject have not been lacking. Magnusson has followed up his Monograph of Scandinavian Acarosporae by discovering yet more new species of the genus (1924) from various European countries—one from Ireland, *A. opaca*, regarded previously as *A. fuscata*. He has also (1926) published critical notes on a number of other European lichens. His study (1925) on the *Rivulosa* group of the genus *Lecidea* goes into the question of affinities: the group was first defined by Th. Fries as having large apothecia, with pale hypothecium and small spores, the paraphyses being usually dark-brown at the tips. Magnusson adds other features, such as the well-marked hypothallus, and the absence of thalline reactions. All the species of the group grow on granitic rocks except a corticolous form of *L. rivulosa*.

Du Rietz (1924) has given us a number of careful papers on various lichens; special attention being devoted to Parmeliae. Among others he has made a study of *P. perlata*: he suggests discarding this name as of mixed import, his view being based on the lichens of Scandinavian herbaria. In Great Britain the species has always been well defined and understood. The first recorded and described specimen—*Lichenoides clausum perlatum* of Dillenius (*Hist. Musc.* 1741, p. 147, t. 20, Fig. 39 *A*, *B*, *D*, *E*)—was examined and confirmed by Nylander and Crombie (*Journ. Linn. Soc. Bot.* XVII, p. 567, 1880). It is one of our commonest British lichens, and in this country is not confused with any other. Crombie distinguished specimens with sparse black cilia on the edge of the thallus as var. *ciliata*. Du Rietz included Crombie's variety along with *P. proboscidea* Taylor, under *P. crinita* Ach. Acharius's species has the priority but it differs specifically from *P. perlatus* var. *ciliata*. Du Rietz further describes *P. trichotera* as "with lobes sparsely and shortly ciliate" evidently identical with Crombie's var. *ciliata*†.

Another change in nomenclature proposed by Wainio and accepted by continental lichenologists may also be noted here. It concerns the familiar British lichen *Parmelia caperata*—*Lichenoides caperatum*, etc. of Dillenius and *Lichen caperatus* L. An examination of the Linnean herbarium at Burlington House,

* See p. 253.

† A specimen kindly sent by A. Zahlbruckner confirms this view.

London, revealed that the only specimens of *Lichen caperatus* there belonged to *Cetraria pinastri*. The name *caperata* has therefore been given to the *Cetraria*, though Linnaeus based his account of *Lichen caperatus* on Dillenius's description and on his drawings as given in *Hist. Musc.* p. 193, Figs. 97 *A* = *P. caperata*, infertile; *B*, smaller state; *C*, fertile condition (*vide* Nylander and Crombie, *tom. cit.* p. 573). Surely such a clear account should weigh heavily against any importance being attached to specimens of mistaken identity and allow these two specific names to rank at least among *nomina conservanda*.

In yet another study (*Bot. Not.* 1924) Du Rietz discusses *Parmelia cetrata*—which name, we, following Wainio, had substituted for *P. perforata*, judged to be solely an American plant. Du Rietz has found from his study of herbaria that *P. cetrata* is also an American species and without soredia, and he revives for the European plant the name *Parmelia reticulata* Tayl., one of the later synonyms. All three species are distinguished by a delicate white reticulation on the upper surface of the thallus.

Hillman (1926) has also given attention to the systematy of Parmeliae in a discussion of *Parmelia incurva* and *P. centrifuga*. The latter dates from Linnaeus and has often been confused with *P. conspersa*. We have as yet no specimen from our own country. *P. incurva*, distinguished by yellow soredia, was originally published by Dickson (1793) as *Lichen multifidus*, by Persoon (1794) as *L. incurvus*. Dickson's name takes priority unless it is considered to be forestalled by *Lichen multifidus* Scop. (1772) which is a *Collema*, and could never have been confused. Dickson gives a good figure of his plant.

Hilitzer (1924) has contributed a critical account of Parmeliaceae in Bohemia. In the *Parmelia* family he includes three genera—*Candelaria*, *Parmeliopsis* and *Cetraria*; he has classified *Evernia furfuracea* as a species of *Parmelia*. Following the method of Nylander and Hue, Hilitzer has arranged his species in "stirps," thus indicating his view of relationships.

Oxner (1926) in his study of Siberian lichens from Lake Baikal records *Cladonia alpestris* f. *orientalis* f. nov. a form that, in his view, represents a geographical race which inhabits Siberia and is also found westwards towards the Urals. The form *sibirica* Mereschk. he finds is not purely Siberian; it is a mountain plant in Asia and also in Europe. *Cetraria odontella* and *C. Richardsonii* were found in fruit.

Magnusson has been working for some time on the northern species of *Stereocaulon* and has now (1926) published a Monograph of the genus in Scandinavia. He has established twenty-three species, with numerous varieties and forms. In the introduction he gives an account of the herbaria he examined and

of the collections made by himself, or which have been submitted to him by other workers. There follows a study of the anatomy of the vegetative structures, of the reproductive bodies and of the cephalodia. These latter bodies are of considerable taxonomic value as they differ in form, and in the type of blue-green algae present in their tissues. Systematy and distribution are also discussed. Many of the boreal species are circumpolar: they are also not infrequent on the higher grounds of more southern countries.

Bachmann (1926) gives a detailed anatomical study of a minute *Stereocaulon* considered by Nylander as an autonomous species and named by him *S. tirolense*. Arnold had referred the plant to *S. alpina* but Bachmann by his careful and exact research has vindicated Nylander's view. Magnusson has also taken that view. The lichen was known from a few localities in Tyrol, but has now been found by Magnusson in Hellbom's herbarium at Göteborg, collected in Finland on granite rocks and associated with *Parmelia sorediata* and several crustaceous lichens.

Du Rietz (1924) has published a valuable summing up of Scandinavian Alectoriae. He recognises ten species with varieties and forms, and these include practically all the European species.

The same author has prepared (1926) a synoptic arrangement of Scandinavian Ramalinae: they all belong to one section, *Bitectae*, distinguished by the chondroid elements in the medulla which form either separate strands or a definite ring within the cortex; the species are further arranged according to the presence or absence of soredia and the position of these on the thallus.

In the first instalment of a great work proposed by Du Rietz, a "*Synopsis Lichenum*," the genera *Alectoria*, *Oropogon* and *Cornicularia* are dealt with. The author in some cases has replaced diagnoses by helpful keys to the species. Each species has a more or less full synonymy with many instructive notes. Such a work along with Zahlbruckner's *Catalogus* will enrich Lichen literature and be of very great assistance to lichenologists. We may add that the genus *Cornicularia* includes species such as *Cetraria aculeata* and *Parmelia cornicularia* (*P. tristis*) which were not quite at home in these other genera.

Malme (1926) suggests changes in classification in his work on *Lichenes Blasteniospori* in Brazil (Regnell Herbarium). He places all the lichens with colourless polarilocular spores in one family—Teloschistaceae—under three genera *Callopisma*, *Xanthoria* and *Teloschistes*. He considers that the old generic name *Placodium* (Hill, 1751) accepted by Wainio and others (including the writer of this paper) is of too mixed import. *Callopisma*

takes precedence over *Caloplaca* and cannot be discarded, while *Blastenia* is redundant: thus the familiar *Placodium elegans* becomes *Callopisma elegans*! Might we not here again appeal to the rule of *nomina conservanda* for *Placodium* as a genus of *Blasteniospori*?

In an account of Chilian lichens (1925–26) Zahlbruckner records and discusses *Roccellina condensata* Darb. In his opinion *Roccellina* is not worthy of generic rank, and is only a section of *Dirina* differing in the somewhat placodioid thallus; a still more advanced thallus is found in *Combea*. Zahlbruckner traces a line of development from *Schismatomma* to *Dirina* and up to *Roccella*, and points out that the two genera *Reinkella* and *Ingaderia* with lirellate apothecia further confirm the relationship of Roccellaceae with Graphidaceae. He considers that in the Roccellaceae, genera, such as *Roccella*, with a fastigiate cortex are of an older type than those in which the cortex is formed of parallel hyphae.

Frey (1926) describes a Swiss lichen *Toniniopsis obscura* gen. et sp. nov. It is somewhat peculiar in thalline structure, being crustaceous but almost entirely plectenchymatous. Apothecia lecideine and spores 3-septate. The nearest affinity is with *Toninia*.

Extremely helpful systematic work on Verrucariaceae has been contributed by Zschacke (1914 and 1924) for Middle Europe. His descriptions are valuable (in *Staurothele* he carefully describes the hymenial gonidia), and there are full critical notes on systematy.

In 1922 Ove Høeg published a paper on Norwegian species of *Nephroma*, a genus distinguished from *Nephromium* by the bright green gonidia, and he has more recently (1924) published a systematic account with keys to the species of Norwegian corticolous Pertusariaceae and Thelotremaceae, the latter represented by one genus *Phlyctis*. In the full descriptions given large use is made of chemical reactions.

A new primitive family of tropical lichens, Cryptotheciaceae, has been described by myself*. The material was found in a collection of lichens belonging to the late Dr Stirton, a noted lichenologist in Glasgow, which had been sent to the British Museum, London, for examination. A series of specimens from India, Rangoon and Western Africa (Cameroons) had been received by Dr Stirton from various collectors about fifty years ago. They were all, to outward appearance, sterile crusts, but Stirton had examined them and had published as a result "*Cryptothecia subnidulans*," which he considered nearly akin to

* See *Transactions*, XI, pp. 189–96 (1926). Readers please note a mistake in the numbering of the plate figures.

Arthoniaceae. The thin crust of all the specimens is of the usual lichen structure, but deeply embedded below the gonidial layer are scattered "perithecia." Each perithecium is a solitary ascus with a peridium of loosely interwoven hyphae; the ascus contains one or up to eight spores. A number of specimens had been examined by Stirton and were labelled *Cryptothecia*.

There has been found material for two genera, *Cryptothecia* and *Stirtonia*, and six species, and their affinity in lichens has been judged to be with Mycoporaceae; in fungi with Myriangiales or Plectascineae. A specimen sent to me by Professor Van der Byl from Natal gives an additional locality for *Cryptothecia subnidulans*.

These notes on systematic work would be incomplete without the record of Keissler's careful studies on lichen parasites (1923, 1925): some of these are true lichens, others are fungi. An exact account of them and of their systematic affinities either among fungi or among lichens is very welcome.

Distribution.

Lichens of Temperate Lands. The study of lichens in the field as well as in herbarium and laboratory has not been neglected. Gonçalo Sampaio in two papers (1922, 1924) has greatly enlarged the record of lichens in Portugal, by adding species new to the country and by extending our knowledge of the distribution of familiar plants. He has continued the work begun by Coutinho (1916) who published a list of 298 lichens. Zschacke (1926) has compiled a list of lichens of the Davos Valleys in Switzerland. Bouly de Lesdain (1922 and 1923) has dealt with European forms, some new to science. Maheu and Gillet have added to Spanish lichenology, including Tangiers and the Canaries in their survey. In Italy Eva Mameli (now Signora Calvino) has listed 200 species or varieties for the Province Emilia, of which 128 are new to the province, while 30 are new to Italy. Zahlbruckner has published lists for Austria and for S. Africa (1926). These works and others are recorded in the Bibliography.

In our own country the enumeration of lichens collected during the forays of the British Mycological Society has been mostly undertaken by Knight (1922–5) and has opened up districts not previously examined. Watson (1925) has given in *Lichenological Notes* a new species, *Stenocybe bryophila*, and a genus new to Britain, *Clathroporina*, hitherto reported only from tropical countries. Most of the species are corticolous: the new one, *C. calcarea*, was found on limestone. It recalls the occurrence of *Anthracothecium*, also an exotic genus, in W. Ireland.

Watson (1925), in a paper on the Bryophytes and Lichens of Arctic-Alpine Vegetation, has compared the lichen flora of the Highlands of Scotland, the mountainous regions of Wales and of the English Lake District with those of other countries. He found that the species on the Grimsel Pass, Switzerland (7000–8000 ft.), were largely the same as those on the higher parts of Ben Lawers (3000–4000 ft.).

A list of lichens for the Ingleton District of Yorkshire has been compiled by Jones (1925). Rock lichens were better represented than those on trees, probably owing to the presence of smoke. Calcareous rocks were fairly rich in forms as were limestone walls. Boulders of millstone grit on the north-west side of Ingleborough were rather barren, those on the east side of the mountain were more productive.

A preliminary account of lichens in the Isle of Man by Hartley and Wheldon (1927) is in course of publication. The work had been well-nigh completed before the lamented death of J. A. Wheldon, a great naturalist and a delightful co-worker. Now it is being issued by Hartley. As the whole island is subject to sea-spray, the lichens might fairly be classified as all maritime or sub-maritime. This preliminary account deals mainly with the topography of the island and the conditions of temperature, exposure, etc., and interesting comparisons are made with the marine lichen-flora of Howth as worked out by M. C. Knowles, and with the coast flora of Lancashire. The Manx dunes are drier, more covered with pebbles and with less of shell-lime than the dunes of Lancashire: so the Cladoniae are more abundant as are crustaceous species on the pebbles. The island contains numerous hills but none of them are high enough to attract an alpine or mountain flora, though *Rhizocarpon geographicum* is found on the upland boulders; the hill species that do occur are mostly infrequent and not luxuriant.

An important paper has been hitherto unfortunately overlooked, in which Häyrén (1914) gave an account of the belts of vegetation on the sea-shore at Tvärminne. He had found, as did Frey in Switzerland, that the types of rock are important—flat rocks, boulders of various sizes, or rock faces. Temperature, insolation, wind and sea-water, however, affect the vegetation almost as much as geological and chemical conditions. Häyrén's observations coincided with those made by M. C. Knowles*, that the coast vegetation formed distinct zones or belts: Häyrén gives (1) sub-littoral, (2) lower littoral, (3) littoral, (4) upper littoral, (5) supra-littoral, and (6) supra-marine. Lichens such as *Verrucaria maura* appear in belt 5, supra-littoral; the higher belt (6) is sprinkled with *Placodium murorum*, above that with

* *Lichens*, p. 379.

Rhizocarpon geminatum, *Parmelia prolixa*, *Ramalina* spp. and further towards the land *Parmelia saxatilis*. Nitrophilous lichens, as so frequently noted, inhabit the rocks frequented by birds. Häyrén has listed 138 lichens from the sea-rocks of Tvärminne. The same maritime belts were noted by Hartley and Wheldon in the Isle of Man (1927).

Lichens of the shore also find a place in Du Rietz's study of vegetation in Gothland (1925). He notes two associations on the lime rocks of the sea-cliffs: (1) non-halophilous, and (2) halophilous. Composing the first were the lichens *Thyrea pulvinata*, *Collema multipartitum*, *Placynthium nigrum*, *Verrucaria nigrescens*, *Lecanora calcarea*, *L. atra* and others. The second halophilous association included more essentially maritime lichens, *Verrucaria maura*, *Lichina confinis*, etc.; these lichens, living under the influence of sea-water, developed on any kind of stone, and in the next higher zone *Caloplaca marina* was also fairly frequent on different kinds of rock; in the upper regions further removed from spray the influence of the substratum again became more marked. Du Rietz noted also that lichens on calcareous rocks were similar to those on bird-frequented siliceous rocks, and he suggests that the similarity may be due to the presence of lime in the excrement of sea-birds or in the natural alkalinity of the excreta. Wheldon and Wilson (1913)* noted in their account of Arran lichens the same indifference of lichens by the sea to the substratum.

Du Rietz has given also a clear account of the inland associations: on the ground, of lichens associated with phanerogams (grasses mostly) and, on rocks, pure associations of lichens, these being strongly influenced by the type of rock.

A study of mountain distribution in Central Europe is contributed by Los (1923) in his Brdage paper. He notes two distinct areas of elevation: the first from 200–400 m. in which there are few lichen plants; and a second from 450–636 m., a region of quartzite, with glacial remains. There he found *Rinodina oreina*, *Parmelia encausta*, *P. Mougeotii* and *P. stygia* with other Alpine species. On the western conglomerate mountain (650–657 m.) lichens were rare owing to the unfavourable substratum. Patches of grauwacke bore subalpine species and in the mountain streams he found *Bacidia inundata*, *Aspicilia lacustris*, *Verrucaria hydrela*, *Dermatocarpon fluviatile* and *Staurothele fissa*.

Du Rietz (1925) gives an account of the distribution of *Parmelia Kernstockii*: the species resembles *P. caperata*, but has pseudocyphellae and different soredia. It was first detected by Bernt Lynge and A. Zahlbruckner in the Tyrol, but an examina-

* *Lichens*, p. 379.

tion of herbarium material has supplied records from S. Austria, Asia (China), Africa (Kenya), and from California.

Hillmann (1923 and 1925) has done equally fine work for the Province of Brandenburg. In the first paper he tells us he drew largely on Egeling's records of lichens (1878 and 1883), and after him on the work of Otto Jaap (1902) and others. He has verified and published 353 species for the province. In his second paper (1925) he has brought the list up to 361 species and has widened the knowledge of distribution.

Meylan (1922) has contributed new records as well as new species for the Jura region. Osterwald (1923), in giving a series of localities for *Bacidia chlorococca* in Brandenburg, comments on the fact that in spite of its abundant growth on tree trunks it had only recently been discovered in the province: the thallus so strongly resembles a layer of green algae that close observation is required to distinguish the presence of the lichen. Erichsen (1923) published a record of lichens for Schleswig-Holstein with a careful account of habitats, localities and dates. It is interesting to find *Verrucaria maura* listed as the first record for Germany of that maritime species.

Josef Anders (1924) has followed up his study of conditions on the Isergebirg by an account of the lichen flora of the small turf-moors that occur amongst the woods of that region. The older branches of the conifers bear luxuriant plants of associated Cetrariae, Parmeliae, etc., while on the soil and on stumps there is another series mostly Cladoniae. The Buchberg, the highest basalt mountain in Middle Europe, was explored, but in general, the basalt was not exposed and the specimens collected were mainly corticolous. Anders (1926) gives also a sketch of lichens in the neighbourhood of Krimmel in Salzburg. The centre of the district was the Krimmel waterfall which supplied a moisture-laden atmosphere favourable to large foliose forms.

In a paper on lichens of Moravia, Suza (1925) presents a phytogeographical study of the conditions in Central Europe. From one direction "holarctic" species have come down from the extreme north and are to be found on the high mountain chains: they are evidently glacial relics from the arctic tundra. A few xerophytic species from the Mediterranean have advanced inland from the south and south-east. He gives lists of lichens for the different localities and for the several substrata, organic and inorganic. Some xerothermic lichens are also recorded: *Cladonia foliacea* var. *convoluta*, *Solorinella asteriscus*, *Lecanora crassa*, *Thyrea pulvinata*, etc. His list for Moravia is 788 species belonging to thirty-four families.

In two other papers (1923, 1925) Suza gives results of various collections: in the first he records lichens from the Trencin

district, noting the absence of Parmeliae on calcareous soils and the scarcity of Cladoniae; in the latter paper, "Lichens des chênaies," he gives a list of epiphytic lichens found on oaks of great size and age that formed part of a virgin forest on the Teresva between Czecho-Slovakia and Roumania.

An exhaustive study of lichen distribution has been carried out by Räsänen (1927) for the lichens of North Finland which he has correlated with the topography and climate of the country. The different lichen substrata are examined in great detail: sea-rocks, loose stones in fields and in woods, as mountain rocks or in caves are passed in review. Stones in the open are, he finds, more densely covered with lichen vegetation than those in woods, and he adds that being more recently exposed than those in woods they have not yet been so much invaded by mosses. In caves he found lichens that naturally grow in shady situations; he notes in these the prevalence of red or yellow colours and compares that phenomenon with the red coloured algae that inhabit deep waters. Frey also (1921) gives the bright yellow *Acarospora chlorophana* as a cave-dweller. Nitrophilous lichens receive special attention: some seem to be absolutely dependent on a supply of ammonia, others tolerate its presence, while the large majority avoid it altogether.

Epiphytes were studied according to the tree and to the position on the tree; those on decorticated trunks and on wood he classes as "lignum" lichens and he publishes lists of the lichens found on the different woods and trees—pine, willow, etc. We have had no such detailed work since Arnold in 1891* gave us the lichens he found on each kind of tree.

In North America the lichens of the Lake George region have been enumerated by Burnham in a series of papers (1922). Merrill publishes (1924) a number of Cladoniae not only new to America but new to science; they were largely collected in the Southern States. Merrill also determined the lichens collected by Millspaugh and Nuttall in California. New Cladoniae from Massachusetts have been contributed by Robbins (1923 and 1924). From Western Pennsylvania a preliminary report was published by Giardini in 1922.

Polar Lichens. In Arctic regions records have been made of lichens in Spitzbergen and Bear Island. Summerhayes and Elton, in their accounts of the Oxford University Ecological Expedition (1923), included a considerable number of lichens (forty-two species determined by R. Paulson) in the various plant associations studied by them. Bernt Lynge has also devoted attention to the same regions which he proposes to visit himself. In his Spitzbergen paper (1924) he summarised the work of

* *Lichens*, p. 364.

several collectors in connection with Swedish and Norwegian expeditions. The lichens of Bear Island (1926) he has described in more detail, with added or revised diagnoses and various biological and geographical notes which should be of great service to students of Arctic lichens. He has enumerated 185 species, a large number for a comparatively small Arctic area. Lynge considers that plants in polar lands must either be such as are well adapted to the extreme conditions under which they live or be profoundly modified. Flowering plants have a better chance as they retire underground during the winter. Many lichens, however, though always exposed, are "adapted" and develop well, *e.g.* Caloplacaceae, Cetrariae and Gyrophorae. Others, especially crustaceous forms, are altered sometimes almost beyond recognition: species with normally well-developed thickish thalli are reduced to a few apothecia with some thin scattered areolae which frequently take on a warted or pyramidal form. The apothecia in structure, colour, spores and chemical reactions remain fairly constant and give the chief clue to specific determination.

Soredia and isidia are only poorly developed. Du Rietz had already noted this as well as the scarcity of apothecia in his paper on isidia and soredia, and concluded that dissemination, in Arctic climates at least, must be by means of broken portions of the thallus.

Magnusson (1926) has given us a study of the Acarosporae, brought from Novaya Zemlya in 1921 by the Norwegian Expedition. The species (ten in all) were in good condition.

Arctic lichens have been studied by Merrill (1924) in Northern Canada. Those from the Arctic coast were collected along the 70° parallel. A territory thirty miles inland from Alaska and another on the Coppermine River were also explored. The lichens were found on rocks by the shore, on pebbles, old bones, drift-wood and tundra formations, and a few on the dead branches of living trees. Crustaceous forms were most in evidence; they were well developed and fertile and entirely covered the rocks. Three species only were exclusively Arctic as far as N. America is concerned: *Cetraria chrysantha, Polyblastia scotinospora* and *Verrucaria striatula* f. *dealbata*. All the others occur also in mountainous regions further south. Merrill remarks that climatic conditions are unfavourable to rapid growth, and he judged that species in such climes might persist for a hundred years practically unchanged.

Lichens from Tropical or Subtropical Lands. Two small collections of lichens from the Far East have been examined by R. Paulson. His first report (1925) relates to the specimens brought from Mt Everest by Dr T. Howard Somervelle: they

were collected in the vicinity of the route followed by the explorers above the 14,000 ft. level; very few were found above 17,000 ft. Paulson gives a list of thirty-one, an addition of ten to the flora of the Alpine Himalayan system. A previous collection on these great heights had been made by Sir Joseph Hooker in 1849, and in both collections were found several species common to the Arctic lichen-flora. An endemic species, *Letharia flexuosa*, discovered by Hooker in Sikkim, was found on Mt Everest and it has also recently been reported by Professor J. W. Gregory from the Alps of Chinese Thibet. Paulson found the Mt Everest plants in healthy condition and the gonidia sporulating freely. Two new species are described.

The second paper (1926) gives an account of lichens from Sumatra and Timor in the Malay Archipelago. The most interesting is a new species, *Anzia Forbesiana*. Paulson has figured the strong rhizine which arises on the lower side of the medulla and pushes through and beyond the dense hypothallic cushion.

South America has always had considerable attention from lichenologists. Herzog (1922) has now given a list of the lichens collected by him in Bolivia. They were revised by Zahlbruckner and give a fair indication of the types of lichens prevalent in that country. Malme has issued three papers dealing with the collections of the Regnell Expedition. The first of these (1924) deals with the tropical families, Astrotheliaceae, Paratheliaceae and Trypetheliaceae. Two species, *Astrothelium punctulatum* and *Trypethelium annulare*, are notable and unusual in that they give rise to hypertrophy in the periderm of trees and may thus be considered as parasites giving rise to disease. The second paper (1925) is on Collemaceae. Malme finds that these blue-green lichens are equally abundant in warm temperate lands and in the tropics and that the same species occur over a wide area. Collemaceae grow frequently on soil but in the regions examined all soil lichens were rare, owing possibly to the very heavy rains. South American lichens have also received attention from Bernt Lynge (1924) who has collated species of *Parmelia*, *Candelaria*, *Teloschistes* and *Pyxine* contained in herbaria at Upsala, Stockholm and Berlin. In another paper (1924) he sums up what is known of South American Anaptychiae and Physciae, most of the data from Malme's collections in Brazil and La Plata. Questions of nomenclature and determination are discussed.

Malme (1926), in his paper on Brazil lichens dealing with the *Lichenes Blasteniospori** (1926), does not consider that these well-marked lichens are as widely distributed as, for instance, the blue-green forms. He rather questions the determination of

* See also under Systematy, p. 245.

specimens that would give support to such an estimate. Thus the Brazil varieties of *Teloschistes chrysophthalmus* are quite distinct from the European forms. On the other hand *Callopisma elegans* differs in no particular. He remarks on the probable great age of many lichen species: the similarity of lichens in Africa and in S. America may be due, he considers, to ancient geological conditions.

A. Zahlbruckner (1925–6) has contributed a paper on the lichens collected by Skottsberg in Chili while on the Juan Fernandez Expedition. They are from two provinces, Coquimbo and Santiago, in both of which the rocks are of volcanic origin. Most of the species are saxicolous, a fair number new to science. Zahlbruckner notes there, as elsewhere, the predominance of the genus *Buellia* on volcanic rocks. From the same author we have a paper (1926) on the lichens of Easter Island along with a description of three new species of *Buellia* in addition to those already described from Juan Fernandez.

Previously only three lichens had been recorded from Easter Island. Zahlbruckner records twenty-two species belonging to twelve different genera, several of them new to science. They grew mainly on volcanic rocks and, as elsewhere, Buelliae are partial to that substratum. Fruticose and foliose lichens were extremely rare, and only one blue-green species, *Heppia Guepini*, was collected.

In a posthumous paper by the lamented Lincoln Riddle, an account is given of some West Indian lichens from the Isle of Pines. One new genus was found, *Monoblastia*, belonging to the Pyrenulaceae, and distinguished by simple spores.

Lichens in the Philippines—their occurrence and distribution—have been discussed by A. W. Herre (1924) from his own observations in the Islands. He remarks that at first sight there would seem to be no place for lichens in the Manila region. "The ground for forty miles round the city has been under cultivation for many generations; only a few lichens appear on the palms or on old bamboos." Again in the forests only the trees along the edge get sun and air sufficient to induce much lichen growth, though the trunks of the trees, especially the younger ones, may be covered with Graphideae or with blotches of immature plants. If it were possible to reach the tops of the trees where there is light and air, a lichen flora would be found of great variety and richness. Vainio as we know has published (1921) quite a large lichen-flora for the Philippines. Malme (1924) in his account of Brazil Collemaceae had remarked on the greater abundance of *Leptogium* species on the trunks of trees on the outskirts of the woods though some grew well in the deep shade.

Lichen Succession. In the study of lichen distribution and also of ecology, the substratum has to be regarded as of the first importance, but room to extend is also necessary, many crustaceous and other species of unlimited growth requiring large areas for development. Hence arises a struggle for foothold and position, a phase of lichen study that is full of interest, and writers have recorded their observations on plant succession and dispossession from the days of Linnaeus onwards. One such sketch is given by Häyrén (1914) as to the vicissitudes of a *Parmelia saxatilis* association in its effort to establish itself: if the area had been already occupied by crustaceous or foliose species the *Parmelia* spread over them; *Parmelia conspersa* in young stages could alone withstand the invader, though occasionally the crustaceous *Lecanora atra* might spread over the older patches of *Parmelia saxatilis*. In this confused growth are entangled particles of soil and sand important in soil formation; finally *Parmelia saxatilis* becomes established as the dominant lichen.

Frey (1921) traced the colonising of zenith flats: first by species of *Rhizocarpon*, *Lecidea*, *Biatorella*, *Gyrophora*, *Lecanora* and the moss *Grimmia*. After a time the *Gyrophora* species ousted all the others, the *Gyrophoretum* association becoming so dense that all the crustaceous species were overwhelmed and ultimately destroyed. Again he noted that purely crustaceous forms meet and coalesce, but when species with a stouter squamulose thallus arrive, such as *Biatorella testudinea*, these spread over the others by means of their lobed edges. Forms still more efficiently lobed such as species of *Placodium* or *Physcia* are still more capable of dispossession.

Motyka, however, has judged (1926) that a space already occupied by crustaceous species is not easily invaded by *Gyrophora* as its spores will not germinate on organic material: the first colonisers persist, therefore, as members of the final association. True members, he holds, are the plants which are most suited to the prevailing conditions, which can spread over large areas and are not easily ousted.

Bernt Lynge (1924) has recapitulated the struggle for place as observed on a stone from Spitzbergen. The first coloniser had been *Rinodina milvina*, entirely crustaceous, which in time was overgrown by *Lecanora melanophthalma* of a stouter, more squamulose nature, by *Physcia caesia* and *Gyrophora arctica*. Finally the powerful Gyrophorae, with free lobes, had overshadowed and killed out all the other denizens of the stone. No other lichen was left except fragments of *Candelariella vitellina* which had settled wherever possible except on the thallus of the Gyrophorae.

ECOLOGY.

Colonisation. This aspect of lichen growth, so closely associated with "Lichen Succession," has received special attention from several workers. Frey (1922) in a note insists on the importance of lichens and mosses as pioneers of colonisation. On dry freely-exposed rock faces, lichens arrive very slowly, later follow mosses and phanerogams. On damp rocks the advance is more rapid: crustaceous species—Rhizocarpons and Aspicilias—settle first; foliose and fruticose forms follow and cover the rocks: a lichen-moss association at length becomes established. Frey (1921) is convinced from his own observation that the fungus in such lichens as *Rhizocarpon* develops first as a hypothallus: they are thus on a par with Graphideae where the fungus penetrates the bark and may persist without its symbiont alga for some time. In the case of the rocks he does not think that soredia are the agents of dispersal as there is no foothold for them. He argues further that as the breaking down of the thalline areolae is a pathological process these areolate particles are not in a condition to start new growths. This view is in opposition to the one generally held that the areolae are often set free by the action of external agents such as wind and rain, that they are in a perfectly healthy condition and often the chief agents of dissemination.

An interesting pioneer coloniser has been discovered by Kuppfer (1924)—the plant *Stereonema chthonoblastes* Kutz. It was first described as an alga, but is now recognised as a primitive lichen resembling the early stage of a crustaceous *Lecidea* or *Biatora*. The hyphae are associated symbiotically with several forms of green unicellular algae and as the resultant lichen covers large tracts of sand-flats it is of considerable importance in preparing the way for other plants. It has been reported from Danzig and from Riga and most probably occurs elsewhere.

Dissemination. Two important papers by Frey were unfortunately overlooked in my previous reviews of lichen literature. The first, already referred to, "Vegetative Relationships in the Grimsel region" (1921), dealt with lichens as part of a large survey of general vegetation. He strongly emphasised their pioneer work: given sufficient moisture they can populate the bare rocks; dry rocks remain barren; on rocks subject to dripping water Gyrophorae develop; where water trickles the rocks become more than half-covered with a variety of species, *Rhizocarpon geographicum* being the most abundant owing, Frey insists, to the capacity for long endurance of its hypothallic growth.

On the zenith flats which are usually rough—partly from glacier action—the rocks become covered with a series of crustaceous forms along with species of *Gyrophora* and with the moss, *Grimmia* sp. Finally there is formed a true *Gyrophoretum* as the crustaceous forms are crowded out by these larger foliose lichens. On the flat rocks where birds and marmosets congregate, the lichens of the above association at length disappear and are replaced by nitrophilous species: *Aspicilia cinerea* and *Lecanora saxicola* flourish.

On shaded rocks other types are found—*Pertusaria corallina*, *P. lactea*, etc. If, however, the shade gives place to lighter conditions—as when trees are cut down—other larger lichens predominate, such as *Parmelia saxatilis* and *Umbilicaria pustulata*. On damp slanting or overhanging flats *Gloeocapsa* algae form the first vegetation; they are succeeded by aquatic mosses and by the blue-green algae *Stigonema* and *Scytonema*; finally by an *Ephebe lanata* association, *Ephebe* having *Stigonema* as algal symbiont.

The various types of rock have been designated in his second paper (1923–24) as flat, vertical, sloping, overhanging, grotto faces and basal. It is on the top flats that nitrophilous lichens are most abundant.

Meylan (1926) also has emphasised the selective character of lichen vegetation in his examination of an erratic "bloc" in the Jura. The boulder, a mass of gneiss, rested on a calcareous base; both rocks had the same exposure. In all forty-seven lichens were found: twenty-four on the boulder, twenty-three on the support. Among all these only six species were common to the two types of substratum.

D. Alfred Hilitzer has recorded the results of recent work in Bohemia in a series of papers (1921–5). One of the more important deals with the lichens of the Labe Plain. It lies to the north of Prague and scattered over it are isolated dry sun-warmed rocks, either lydite or schist, rising to a height of 269 m. On the south and south-east smooth sides of the lydite he found a *Rinodina oreina* association, an extremely xerophilous group. On the summit of the rocks where birds rest, *Ramalina strepsilis* and other lichens form a nitrophilous association, while to the north and north-east occurs an *Aspicilia caesiocinerea* association. Three extremely xerophilous lichens, *Placodium rubinum*, *Rinodina oreina* and *Acarospora oxytona*, are present on the heated rocks of the plain as well as on the mountains above the high forests: in the driest as in the highest localities they find the atmosphere that suits them. Hilitzer concludes that humidity plays an all-important rôle in the ecology of lichens.

Lichen Associations. Chiefly Saxicolous. Frey (1923–24)

had suggested an improved terminology for lichen associations, adding the suffix "etum" to the dominant member. Thus in an alley of elms and limes, the trunks on the side exposed to wind and rain exhibited a *Parmelietum* composed of *Parmelia scortea*, *P. caperata* and *P. exasperatula* with, to a lesser extent Physicae and nitrophilous spp.—*Xanthoria parietina*, etc. Some or others of the same group occurred on all the trees.

In comparing conditions in the Grimsel with those of the Engadine, in the latter a drier locality, not only are shade lichens absent, but the foliose and fruticose species are smaller, more crowded, and of more compact growth.

From Motyka we have two important papers which form part of an ecological plant survey of the Tatra Mountains. It is a region of high pasture lands, but, here and there, lime dolomite and siliceous rocks or boulders provide a varied substratum. The persistent occurrence of certain definite associations of species is due not only to the chemical constituents of the rocks, but also, as in the Grimsel, to the supply of moisture and to the orientation and insolation or shade of the rock surfaces. Lichen "sociology" represents the response of the plants to these influences.

The first paper (1924) deals entirely with nitrophilous associations which are invariably to be found where birds or small mammals habitually rest and leave their excrements. Motyka describes three or possibly four such associations. They differ according to the abundance or scantiness of the nitrogenous material and also according to the nature and position of the rocks. It is pointed out that many of the strongly nitrophilous (rock) species (such as Xanthoriae) also occur on trees, and indeed, that certain genera are exclusively either corticolous or grow on nitrogenous substrata, also that genera with polari-bilocular spores provide many of these nitrophilous species.

The second paper (1926) on epilithic lichens gives an account of fourteen associations on siliceous rocks and three on calcicolous: the dependence of the lichen species on the substratum becomes very evident in a restricted territory such as the Tatra. The papers give interesting notes on the occurrence and succession of the different species, and on the different types that inhabit lime, dolomite or marl. One of the most frequent siliceous species is *Gyrophora cylindrica* which grows on all limeless rocks in exposed positions, avoiding only moist or shaded situations.

Chiefly Corticolous. Dr Hilitzer (1925) has published a study of epiphytic associations in Bohemia. He notes first the position or "ecology" of the associations and the factors that

are of influence such as substratum, atmosphere and the concurrence of species which he considers as primary factors; as secondary he distinguishes height, distance from the sea, exposition, soil and the special tree conditions. Again he envisages the species that are "eurychoric," that is, capable of living in widely diverse conditions, and those that are "stenochoric" as strictly limited to places or conditions and not therefore occurring in many associations. It is impossible to give any real account of so detailed a study: he follows the method of Du Rietz in counting the plants in uniform small areas or quadrats and gives the name of the dominant plant to the association. In an association, for instance, of *Lecanora subfusca* on *Fagus sylvatica* there are associated twenty-three other lichens and four mosses or hepatics. This association is confined to smooth bark, on the protected side of the tree and the dominant *L. subfusca* occupies more than the half of the area. An association of *Pertusaria amara* on similar types of bark gives twenty-nine associated lichens and five other cryptogams (mosses or hepatics).

In an association—*Pyrenula nitida*—with twenty-nine other plants (mostly lichens) the dominant *Pyrenula* immensely outnumbered all the others, a condition I noted as very striking when collecting near Dublin (1926).

After an account of thirty-three epiphytic associations in which twenty-three are dominantly lichenoid, two algal and eight of mosses or hepatics, Hilitzer (1926) devotes some pages to describing the position on the trunk, the associations differing according to height from the ground and to orientation.

Savicz (1923) has studied the forest formations in the pine woods of White Russia. On the trees there is a rather poor development of lichens: two associations, however, were evident, one on the branches with large pendant species, the other on branches and leaves consisting mainly of *Parmelia physodes*. Species that prefer a smooth bark grew on the upper reaches; on the lower trunks he found large lobed forms (*Peltigera, Lobaria*) which crowd out the mosses. Savicz stresses also the influence of the geological substratum.

Epiphyllous lichens are common in the tropics. In temperate lands only a few are confined to leaves. A number of species, however, frequently develop on leaves as well as branches. Frey (1923) has given an account of those he has noted in Europe such as *Parmelia physodes* on pines; *Candelaria concolor, Physcia tenella, Xanthoria parietina* and several others on *Buxus sempervirens*. Most of them spread from the branch to the leaves. Young thalli of *Physcia tenella* developed on the leaves from the soredial stage and were attached by the whole under surface

to the leaf without, however, piercing the leaf cuticle. In two years they had increased to a diameter of 1 cm.

A different and unusual substratum—decayed wood or wood in walls, roofs, etc.—was studied by Tomin (1918). He noted in three different species, two Ramalinae and one *Evernia*, that the plants in association were all short, crowded and with flattened fronds.

LIST OF PUBLISHED LITERATURE.

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General account of lichens and list of plants in S.E. Sicily.

ANDERS, JOSEF. Die Strauch- und Blattflechten Nordböhmens. II. Nachtrag. Hedwigia, LXI, pp. 351–74 (1920).
A descriptive account of the locality, and a list with habitat, etc. of some of the larger lichens—*Cladonia, Parmelia*, etc.

—— *Do.* III. Nachtrag. Op. cit. LXIII, pp. 269–322 (1922).
A continuation of previous work. Crustaceous lichens are described and also some of the larger forms.

—— Zur Flechtenflora des Isergebirges (Nachtrag). Hedwigia, LXV, pp. 65–84 (1924).
A supplement to a list published in 1923 (op. cit.). Several new varieties and forms of various species are described and one new, *Lecanora* (*Aspicilia*) *sanguinulenta*.

—— Zur Flechtenflora der Umgebung von Krimml in Salzburg. Hedwigia, LXVI, pp. 103–26 (1926).
In the centre of the district is the Krimmel Waterfall which supplies a moisture-laden atmosphere favourable to the growth of large foliose and fruticose forms.

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An examination of historical and current records of lichens in Bohemia.

BOULY DE LESDAIN. Lichenes prope Habanam in Insula Cuba Anno 1914 a Cl. Fratre Arsène Brouard lecti. Bryologist, XXIV, pp. 68–9 (1921).
A short list of species—two new to science—*Endopyrenium Brouardi* and *Tomasiella Brouardi*.

—— Quelques Lichens du Pas-de-Calais. Bull. Soc. Bot. France, LXVII, pp. 217–28 (1920).
A number of lichens and a few new forms are listed. Interesting biological notes are given. Unusual substrata such as iron, bones, leather, etc. are noted with the lichens found thereon.

BOULY DE LESDAIN. Lichens des environs de Versailles. Op. cit. LXVIII, pp. 16–24 (1921).
A supplement to lists already published: several new forms are included.

—— Notes lichénologiques. XVIII. Tom. cit. pp. 203–7 (1921).
The list includes the new genus and species *Henrica ramulosa*. New species are: *Alectoria funiformis*, N. America; *Lecanora Limica*, Portugal; *L. bracarensis*, Portugal; *Lecania Sampaiana*, Portugal; *Acarospora duriana*, Portugal; and *Microglaena Sampaiana*. Several of these are published in collaboration with Dr G. Sampaio.

—— Notes lichénologiques. XIX. Op. cit. LXIX, pp. 766–70 (1922).
Mainly descriptions of new forms and species from widely separated regions. The new species are: *Caloplaca italica* from Italy; *C. Meylani* from the Jura; *C. Mairei* from Greece; and *Lecanora subcenisia* from Cantal.

—— Notes lichénologiques. XX. Op. cit. LXX, pp. 277–83 (1923).
A list of lichens as above. New species are: *Parmelia Sharbaronis*, Liguria; *Lecidea italica*, Valtelline; *Opegrapha vetulinoides*, Italy; and *Verrucaria Sampaiana*, Portugal.

—— Notes lichénologiques. XXI. Tom. cit. pp. 842–9.
A list of lichens as above. A number of new varieties and forms have been described. The new species are: *Aspicilia Meylani*, Switzerland; *Toninia meridionalis* var.; *Buellia Duarte* Samp., Italy; and *Polyblastiopsis myrticola*, France.

—— Notes lichénologiques. XXII. Op. cit. sér. 5, I, pp. 787–91 (1925).
A number of new species are described, most of them from regions round the Mediterranean, S. France or N. Africa.

—— Lichens du Maroc recueillis par M. Mouret en 1912. Mém. Soc. Hist. Nat. du Maroc, N. VIII, pp. 290–9 (1926).
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The lists number 271 species.

CENGIA-SAMBO, M. Licheni di Rode raccolti dal Prof. A. Fiori nell' Agosto 1923. Bull. Soc. Bot. Ital. pp. 123–5 (1924).
Formerly only one lichen, *Ramalina calicaris*, had been recorded from Rodi: Cengia-Sambo has determined a new variety for that species, var. *sorediosa* and a number of other lichens.

—— Due Escursioni licheniche in Piemonte: Alta Valle della Dora Baltea e alta Valle d'Ala. Bull. Soc. Bot. Ital. pp. 181–7 (1925).
For the Val Dora Baltea 68 species are listed; for Val d'Ala 25. Several new forms were found.

CHEEL, EDWIN. Notes on a "Coral Lichen" (*Cladonia retepora*). The Australian Naturalist, I, 2, pp. 183–6 (1924).
A historical account of a beautiful plant and the localities in Australasia where it has been collected.

CHODAT, R. and L. Les Gonidies des Lichens et la Lichénine. Compt. Rend. Soc. Phys. et Hist. Nat. Genève, XLI, pp. 74–6 (1924).

CHOISY (MAURICE PAUTRE). Collection de Micrographies Lichéniques. Lyon, 1927.
A collection of drawings and descriptions issued in loose sheets. Fascicles are to be issued annually.

COUTINHO, ANTONIO XAVIER PEREIRA. Lichenum Lusitanorum Herbarii. 122 pp. Manuel Lucas Torres, Lisboa, 1916.
An account of the study of lichens in Portugal with descriptions. Coutinho chronicles 298 species.

CROZALS, A. DE. Lichens de la butte volcanique de La Garde. Ann. Soc. Hist. Nat. Toulon, pp. 21–7 (1922). See Hedwigia, LXV, Beibl. p. 59 (1925).

—— Florule lichénique des Oliviers dans les environs de Toulon. Ann. Soc. Hist. Nat. Toulon, N. 9, pp. 45–75 (1923). See Bull. Soc. Bot. Fr. LXXI, p. 1250 (1924).
The author collected and determined 89 species and 16 varieties of lichens on the olive trees near Toulon.

—— Florule lichénique des environs de Vizzavona (Corse). Tom. cit. N. 9, pp. 76–115.
Crozals has enumerated 218 species, of which 100 are new to Corsica. Most of them were collected on the mountains.

—— Les Lichens du Massif des Maures. Op. cit. N. 10, pp. 88–116 (1924).

DANILOV, A. Les hyphes des Lichens peuvent-elles reproduire les Algues, et la Chlorophylle peut-elle se former dans ses hyphes? Bull. Jard. Bot. Princip. Républ. Russe, XXI, Fasc. 3, p. 200 (1922). (Paper not seen.)

DARBISHIRE, O. V. Some Aspects of Lichenology. Trans. Brit. Mycol. Soc. X, pp. 10–28, 1 fig. (1924).

—— Structure of *Peltigera* with especial reference to *P. praetextata*. Ann. Bot. XL, pp. 727–58, 4 pls. (1926).

—— Soredia of *Peltigera erumpens* Wain. and *P. scutata* Kbr. Trans. Brit. Mycol. Soc. XII, pp. 52–70, 2 pls. (1927).

DU RIETZ, G. EINAR. Lichenologiska Fragment. III. De Svenska Xanthoria-arterna. Svensk Bot. Tidsk. XV, pp. 181–91 (1921).
Du Rietz finds five species of *Xanthoria* in Sweden. Two of these distinguished by soredia: *X. candelaria* and *X. fallax*.

—— Lichenologiska Fragment. IV. Op. cit. XVI, pp. 69–76 (1922).
Three species of *Cladonia* are fully discussed: *Cl. Delessertii*, *Cl. symphicarpia* and *Cl. bacilliformis*.

—— Lichenologiska Fragment. V. Op. cit. XVII, pp. 83–95 (1922).
A varied series of lichens are discussed and described: *Alectoria cincinnata* is considered an autonomous species; the genus *Micarea* is retained.

—— Lichenologiska Fragment. VI. Op. cit. XVIII, pp. 141–55 (1924).
A full account of Scandinavian (= European) species of *Alectoria*.

—— Morfologi och Systematik hos släket *Ramalina*. Särskillt dess skandinaviska arter. Op. cit. XX, pp. 295–8 (1926).

—— Den subantarktiska florans bipolära element i lichenologisk belsyning. Tom. cit. pp. 299–303 (1926).

—— Kritische Bemerkungen über die *Parmelia perlata*-Gruppe. Nyt Mag. f. Naturv. LXII, pp. 63–82 (1924).

—— Flechtensystematische Studien. IV. Botaniska Notiser, Lund, pp. 329–42 (1924).
Notes on *Leptogium rivulare*, *Parmelia cetrata*, etc.

—— Gotländische Vegetationsstudien. Svenska Säxtsociolog. Sallsk. Handl. II, pp. 1–65, 16 figs. (1925).

—— Die europäischen Arten der *Gyrophora "anthracina"*-Gruppe. Ark. Bot. XIX, N. 12, pp. 1–14 (1925).
Du Rietz has concluded that the name *Gyrophora anthracina* is of mixed import.

—— Einige von Dr M. Gusinde gesammelte Flechten aus Patagonien und dem Feuerlande. Op. cit. XX B, N. 1, pp. 1–6 (1926).
The species (nineteen in all) were collected in 1919–24. Du Rietz records a new species, *Pseudo-cyphellaria dubia*; and has contributed notes to several species.

Du Rietz, G. Einar. Vorarbeiten zu einer "Synopsis Lichenum." I. Die Gattungen *Alectoria, Oropogon* und *Cornicularia*. Tom. cit. N. 11, pp. 1–43, 2 maps, 2 pls. (1926).

—— Flechtensystematische Studien. V. Bot. Not. pp. 1–16 (1925).
An account of *Parmelia Kernstockii* from the Tyrol, also recorded from S. Austria, W. Africa and California (similar to *P. caperata* but with pseudocyphellae). Also an account of the *Cetraria lacunosa* group, of the distribution of *Roccella* spp. and a discussion of *Cladonia* sect. *Clathrina*. Du Rietz repeats the mistake of writing *Cl. retepora* as *retipora*.

—— Flechtensystematische Studien. VI. Tom. cit. pp. 362–72.
Studies of *Gyrophora rugifera, Sphaerophorus polycladus, Thysanophoron Pinkertonii* as *Sphaerophorus stereocauloides*, and *Ramalina Roesleri*.

—— Flechtensystematische Studien. VII. Op. cit. pp. 339–40 (1926).
A specimen, *Lobaria mollissima* Samp. from Portugal, has been recognised by Du Rietz as an *Erioderma*, a new genus for Europe.

Elenkin, A. Nouveaux travaux étrangers et russes, concernant ma théorie d'endosaprophitisme et la loi d'équilibre mobile des composants de la symbiose des lichens. Bull. Jard. Bot. Princ. Républ. Russe, xxi, fasc. 1, pp. 65–9 (1922). Russian.
A discussion of the papers published on endosaprophytism.

Erichsen, C. F. E. Neue Ergebnisse der Erforschung unserer Pflanzenwelt. Verh. Naturw. Ver. Hamburg, 1, 4, pp. 9–14 (1923).

—— Beiträge zur Lichenenflora von Teneriffa. Hedwigia, lxvi, pp. 275–82 (1926).
A short list of species: those new to science are *Ocellularia atlantica, Bacidia canariensis, Pertusaria Teguestensis, Rinodina agavicola* and *Buellia Lindingeri*.

Frey, Ed. Die Vegetationsverhältnisse der Grimselgegend im Gebiet der zukünftigen Stauseen. Mit. Naturf. Gesellsch. Bern, pp. 85–281, 11 pls., 5 text-figs., 1 map (1921).

—— Die Bedeutung der Flechten und Moose bei der Besiedlung von Silikatfels- und Silikatschuttböden. Ber. Schweiz. Bot. Gesellsch. Bern, xxxi, p. xxx (1922).

—— Epiphylle Flechten. Mitt. Naturf. Ges. Bern, pp. 1–2 (1923).

—— Die Berücksichtigung der Lichenen in der soziologischen Pflanzengeographie, speziell in den Alpen. Verh. Naturf. Ges. Basel, xxxv, pt 1, pp. 303–20 (1923–4).

—— Flechten. Fortschritte der Floristik. Ber. Schweiz. Bot. Ges. xxx, 5, pp. 73–5 (1926).
A new genus and species recorded in Switzerland: *Toniniopsis obscura* Frey.

Fry, E. Jennie. The Mechanical Action of Corticolous Lichens. Ann. Bot. xl, pp. 397–417, 35 text-figs. (1926).

Fünfstuck, M. Lichenes (Allgemeiner Teil). Engler und Prantl. Die Natürlichen Pflanzenfamilien, viii (zweite Auflage), pp. 1–60, 31 figs. (1926).
The author prepared the introduction of "Lichenes" before his death in Stuttgart, February 1925, in his 69th year.

Gams, H. Aus der Lebensgeschichte der Flechten. I–III. Mikrokosmos, xv (1921/22), pp. 187–90 (1922); xvi (1922/23), pp. 113–18 (1923); xvii (1923/24), pp. 148–54 (1924). See Ber. Schweizer Bot. Gesell. xxxiii, p. 1 (1924).
Paper not seen.

Gandara, Guillermo. Accion de los liquenes sobre otras plantas. Revista mexic. de briologia, 1, pp. 215–20 (1921). See Hedwigia, lxiv, Beiblatt, p. 37 (1923).
Paper not seen.

GATTÉFOSSE, JEAN. Le Commerce de la "Mousse de Chêne" dans l'Égypte ancienne. Le Monde des Plantes, sér. 3, XXIII, N. 23, p. 2 (1922). See Hedwigia, LXIV, Beiblatt, p. 116 (1923).

GENTY, P. A. L'îlot granitique de Mâlain et sa végétation. Monographie phytostatique. Bull. Soc. Bot. France, LXXI, pp. 1069–84 (1924).

The territory is described as an island of granite rocks laid bare by some geological dislocation. The lichens collected (31) were characteristic siliceous species. *Buellia leptocline* was particularly abundant.

GIARDINI, GIOVANNI J. Preliminary Report on the Lichens of Western Pennsylvania. Bryologist, XXV, pp. 100–8 (1922).

GIBBS, L. S. Dutch N.W. New Guinea. A contribution to the Phyto-geography and Flora of the Arfak Mountains, etc. London: Taylor and Francis. 226 pp., 4 pls., 16 figs. (1917).

The paper deals almost entirely with the ecology of phanerogams, but on the summit of Koebré Mt., 9000 ft., the author found on an open plateau, where systematic burning took place, a remarkable association consisting of *Cladonia verticillata*, *C. didyma* and *C. coccifera* which covered the whole area as a uniform grey carpet, about 3 cm. high.

GOEBEL, K. Die Wasseraufnahme der Flechten. Ber. Deutsch. Bot. Ges. XLIV, pp. 158–61 (1926).

HANSEN, H. MØLHOLM. Lichenologiscke Notitser. Bot. Tidsskr. XXXVII, p. 460 (1922).

Cetraria islandica, *Parmeliopsis aleurites* and *Dermatocarpon Michelii* new to Veshjylland are reported.

HARTLEY, J. W., and J. A. WHELDON. The Lichens of the Isle of Man. A preliminary list showing the Distribution of the Species known to occur in the Island. Supplement to The North Western Naturalist, II, pp. 1–12 (1927). To be continued.

HÄYRÉN, E. Ueber die Landvegetation der Meeresfelsen von Tvärminne. Acta Soc. Faun. et Fl. Fenn. XXXIX, pp. 1–193, 15 figs., 1 map (1914).

HENCKEL, A. Sur l'Hélotisme des Lichens. Bull. Inst. Recherches Biolog. Univ. de Perme (Russie) I, p. 1, pl. 1 (1923).

Paper not seen.

HERRE, ALBERT W. Lichens in the Philippines. Bryologist, XXVII, pp. 85–6 (1924).

HERZOG, TH. Beitrag zur Flechtenflora von Bolivia. Hedwigia, LXIII, pp. 263–8 (1922).

Lichens collected by the author and determined by A. Zahlbruckner. The writer presents the list as that of the most outstanding and important lichens of the S. American country.

HILITZER, ALFRED. Lišejníky drabovských křemenců nad Dobrichovicemi. Zvláštní Otisk Časopisu Musea, pp. 1–4 (1921). Czecho-Slovakian.

—— Systematika Parmelií ze skuping *P. olivacea*. Vestník (Prag, 1923), pp. 81–2, *fide* Hedwigia, LXV, Beibl. 59, p. 60 (1925).

Paper not seen.

—— Les Lichens des rochers amphiboliques aux environs de Všeruby. Zvláštní Otisk z Časopisu Národního Musea, 1923, 14 pp. (Prag, 1924). With French résumé.

—— Quelques Lichens intéressants des Krkonoše. Tom. cit. 5 pp. With French résumé.

—— Druhý příspěvek k lišejníkům drabovských křemenců. Op. cit. pp. 3–7 (1925). Czecho-Slovakian.

—— Enumeratio critica Parmeliacearum Bohemiae. Ann. Mycol. XXII, pp. 219–29 (1924).

The author lists with localities, etc. 41 species of *Parmelia* with other allied genera.

HILITZER, ALFRED. Addenda ad Lichenographiam Bohemiae. Acta Bot. Bohemica, III, pp. 3–15 (1924).

—— Étude sur la Végétation Épiphyte de la Bohème. Publ. de la Faculté Sci. Univ. Charles. 202 pp. Prag (1925).

—— Lišejníky křemitých skal v středním Polabí. Les Lichens des Rochers silicieux dans la Partie Centrale de la Plaine de Labe. Zvláštní Otisk z Preslie, III, pp. 10–22 (1923–5). Czecho-Slovakian with French résumé.

—— Notes sur la Production et l'Éjaculation des spores chez le *Solorina saccata*. Acta Bot. Bohem. IV, pp. 52–8, 3 figs. (1926).

—— Addenda ad Lichenographium Bohemiae, ser. 2. Acta Bot. Bohem. IV, pp. 42–51 (1926).

A large and interesting list of species in continuation of a previous lichen-flora. A few are recorded as new to Bohemia.

HILLMANN, JOHANNES. Uebersicht über die Arten der Flechten-Gattung *Xanthoria* (Th. Fr.) Arn. Hedwigia, LXIII, pp. 198–208 (1922).

Hillmann divides the genus into two sections, *Euxanthoria* and *Xanthosolenia*, the latter with one representative, *X. flammea*, distinguished by the apical almost immersed apothecia.

—— Uebersicht über die in der Provinz Brandenburg bisher beobachteten Flechten. Verhandl. Bot. Ver. Brandenb. LXV, pp. 36–75 (1923).

—— Zur Flechtenflora der Mark Brandenburg. I. Op. cit. LXVII, pp. 40–9 (1925).

—— Beiträge zur Systematik der Flechten. Ann. Mycol. XXIV, pp. 138–44 (1926).

HØEG, OVE. Die Norwegischen *Nephroma*-Arten. Nyt Mag. Naturvidensk. LX, pp. 85–97, 1 pl., 3 figs. (1922).

—— The corticolous Norwegian Pertusariaceae and Thelotremaceae. Nyt Magazin, LXI, pp. 139–78, 1 pl. (1924).

Full and careful descriptions of these families. He records one genus in Thelotremaceae, viz. *Phlyctis*.

HOWE, HEBER. A further Note on the Lichens of Nantuckett. Rhodora, XX, p. 40 (1918).

HULTING, J. Lavar från Östergötland. Arkiv för Botanik, XX, 2, pp. 1–80 (1926).

A record of the collectors since the days of Acharius. Thirty-three families of lichens are recorded.

HURST, CECIL P. Wiltshire Lichens in the Department of Botany at the British Museum. Wilts Archaeol. and Nat. Hist. Mag. XLII, pp. 427–50 (1924).

JENNINGS, O. E. Lichens crowd out Mosses. Bryologist, XXVI, p. 4 (1923).

A note giving additional record of the baneful influence of lichens on moss vegetation to the instances cited by McWhorter (Bot. Gaz. LXXII, pp. 321–5 (1921)).

JONES, D. A. Lichens of the Ingleton District. Naturalist, pp. 241–4 (1925).

A list of lichens collected during an Easter meeting of the Yorkshire Naturalists' Union. The effects of industrial smoke were noted.

KEISSLER, KARL. Einige interessante Flechtenparasiten aus dem Herbar Upsala. Ark. Bot. XVIII, N. 16, 24 pp. (1923).

Two new forms were found in the material from Upsala, and critical notes are given on a large number of species.

—— Systematische Untersuchungen über Flechtenparasiten und Lichenoide Pilze. III. Ann. Nat.-Hist. Museums Wien, XXXIX, pp. 162–8 (1925).

Keissler deals with 10 species belonging to different genera and growing on various lichens as parasites. Two of them, *Stagonospora Sandstedeana* on *Cladonia* sp. and *Libertiella Xanthoriae* are new to science.

KEISSLER, KARL. Systematische Untersuchungen, etc. Tom. cit. pp. 194–201.
Keissler reviews 10 different species. He has decided that *Hymenobolina parasitica* is not a Mycetozoon, but evidently his material has been faulty, as the whole development as a Mycetozoon has been carefully followed. He insists on the importance of the genus *Polyschistes* Steiner. Several species recorded under *Lecidea* have been transferred by him to fungi.

KILLIAN, CH., and R. G. WERNER. Cultures pures des Champignons de Lichens. Comptes Rendus Acad. Sci. CLXXIX. pp. 1339–42, 10 figs. (1924).

—— Nouvelles observations sur la culture de Cryptogames d'Alsace. Bull. Ass. Philomatique Alsace et Lorraine: Saverne, pp. 320–7 (1925).

KNIGHT, H. H. Lichens found during the Worcester Foray. Trans. Brit. Mycol. Soc. VII, p. 10 (1922).

—— Lichens of Haslemere District. Tom. cit. p. 225.

—— Lichens of the Windsor Foray. Op. cit. X, p. 9 (1924).

—— Lichens of the Matlock Foray. Op. cit. X, pp. 132–3 (1925).
The lichens were mostly crustaceous species.

—— Bettws-y-Coed Lichens. Tom. cit. pp. 242–4 (1926).
Parmelia, *Lecanora*, *Lecidea* and *Cladonia* are well represented in the list.

—— Lichens of the Tintern Foray. Op. cit. XI, pp. 9–10 (1926).

KUJALA, V. Untersuchungen über die Waldvegetation in Süd- und Mittelfinnland. I. Zur Kenntnis des ökologisch-biologischen Charakters der Pflanzenarten usw. C. Flechten.
Paper not seen (quoted by Räsänen).

KUPFFER, K. R. *Stereonema chthonoblastes*, eine lebende Urflechte. Korrespondenzbl. Naturf. Ver. Riga, LVIII, pp. 111–22, 1 pl. (1924). See also Hedwigia, LXVI, Beibl. pp. 8–9 (1926).

LETTAU, GUSTAVE. Die Flechten der Rheinhalde. Die Flora des Naturschutzreservates der Rheinhalde oberhalb Basel (A. Becherer, E. Steiger und G. Lettau). Verh. Naturf. Ges. Basel, XXXIII, pp. 131–4 (1922).

LINDAU, G. Lichenes novo-guineenses. Engl. Bot. Jahrb. LVIII, pp. 250–4 (1923).
The lichens of the collection Ledermann have been determined and listed.

LOS, V. K fytogeografii horských lišejníků brdských (Zur Phytogeographie der Gebirgsflechten des Brdagebirges). Sep. from "Časopis Národního Musea," Jhg. XCVII, 1, 7 pp. (1923). Prague. See also Hedwigia, LXV, Beiblatt, pp. 15–16 (1925).

LUND, MOGENS. *Cetraria cucullata* fundet i Danemark. Bot. Tidsskr. LX, pp. 460–1 (1922).
Cetraria cucullata new to Denmark.

LYNGE, BERNT. Lichens from the Gjøa Expedition. Vidensk. Skrift. I. Mat.-Naturv. Kl. N. 15, pp. 1–7 (1921).
The expedition to the N.W. Passage was under the command of Roald Amundsen. Most of the specimens were obtained at Gjøa harbour or at Herschel Island.

—— Lichens in the Herb. Gunnerus. Kgl. Norsk. Vidensk. Selsk. Skrift. 1920, N. 3, 12 pp. (1921).
A sketch of the work of Gunnerus, who died in 1773, and an examination of the lichens in his Flora Norwegica.

—— Lavslegten Parmelia i Danmark. Bot. Tidsskr. XXXVIII, pp. 69–78 (1923).
Lynge lists 22 species with localities, etc.

—— Lichens from Spitsbergen (Resultater av de Norske Statsunderstøttede Spitsbergenekspeditioner). Vidensk. I. Kristiania, 1, N. 5, 21 pp., 2 pls. (1924).

LYNGE, BERNT. South American Anaptychiae and Physciae. Vidensk. Skrift. I. Mat.-Naturv. Klasse, N. 16, pp. 1–47, 5 pls. (1924).
Keys are given to the genera. Most of the specimens were collected by Malme in Brazil and La Plata.

—— South American Lichens of the genera *Parmelia, Candelaria, Theloschistes* and *Pyxine*. Nyt Mag. Naturv. LXII, pp. 83–97 (1924).
Lynge has worked through the collections at Upsala, Stockholm and Berlin. New descriptions and critical notes are given.

—— Lichens from Bear Island (Bjørnøya) collected by Norwegian and Swedish Expeditions, chiefly by Th. M. Fries during the Swedish Polar Expedition of 1868. Resultater Norske Stats. Spitsb.-Eksped. I, N. 9, pp. 1–78, 1 map, 2 pls. (1926).

MAGNUSSON, A. H. New or Interesting Swedish Lichens. I. Bot. Not. pp. 401–16 (1923).
Notes on several new or rare species of crustaceous lichens. Magnusson goes into the question of synonymy as regards *Leptogium rivulare, L. Sernanderi* and *L. fluviatile*.

—— New or Interesting Swedish Lichens. II. Op. cit. pp. 377–91 (1924).
A list is given of somewhat rare species, with an account of several Parmeliae, notably *P. infumata*, also of *Baeomyces caprina* A. Magn. previously regarded as *Biatora* sp.

—— New Species of the genus *Acarospora*. Svensk Bot. Tidsk. XVIII, pp. 329–42 (1924).
Descriptions of numerous new species; a number are from Switzerland, but there are also species from France and Portugal and one from Ireland, *A. opaca* Magn.

—— Studies in the *rivulosa*-group of the genus *Lecidia*. Göteb. Kungl. Vetensk. Handl. XIX, N. 4, pp. 50 (1925).

—— Smärre Meddelanden. Svensk Bot. Tidsk. XIX, pp. 111–14 (1925).
Notes on species of rare occurrence in Sweden: *Cetraria normerica, Cladonia caespiticia, Cl. incrassata, Sticta limbata*, etc.

—— Studies on Boreal Stereocaula. Göteb. Kungl. Vetensk.- och Vitterh.-Samh. Handl. XXX, N. 7, pp. 1–89 (1926).

—— New or Interesting Swedish Lichens. III. Bot. Not. pp. 227–37 (1926).
Species new to science or new to Sweden are described. Several additions are made to the genus *Acarospora* and additional localities for some of the species described previously.

—— New or misunderstood European Lichens. Meddel. Göteborgs Botaniska Trädgård, II, pp. 71–82 (1926).
New species are *Lecanora atlantica* (nearly related to *L. intercincta*), *Acarospora Muddii* and *A. pyrenopsoides*; species criticised are *A. versicolor* Bagl. & Car. and *A. umbilicata* Bagl.

—— *Acarospora*. Report of the Scientific Results of the Norwegian Expedition to Novaya Zemlya 1921, N. 34, 7 pp. Oslo, 1926.
Magnusson describes two new species and one variety of *Acarospora*. There is a record of 10 Acarosporae; two new to science: *A. interposita* and *A. Novae Zemliae*.

—— New or Interesting Swedish Lichens. IV. Bot. Not. pp. 115–27 (1927).
Two new species, *Ochrolechia Bahusiensis* and *Lecanora rimicola*, the latter a small lichen of the *Hageni* group.

MAHEU, J., et GILLET, A. Contribution à la connaissance de la Lichénologie espagnole. Bol. R. Soc. esp. Hist. Nat. XXII, pp. 349–57 (1922).
The writers include Spain, Tangiers and the Canaries in their survey. They have listed 48 species.

MALME, GUST. O. A. U. Die Flechten der ersten Regnellschen Expedition. Arkiv för Botanik, XIX, 1, 34 pp. (1924).
A second paper which deals with the pyrenocarpous families Astrotheliaceae, Paratheliaceae and Trypetheliaceae.

MALME, GUST. O. A. U. Die Collematazeen des Regnellschen Herbars. Tom. cit. N. 8, 28 pp.
Malme deals with 5 species of *Collema* and 23 species of *Leptogium*.

—— En my fyndort i Västergötland för *Cetraria normerica* (Gunn.) Lynge. Svensk Bot. Tidsk. XVIII, pp. 548–9 (1924).
Notes on the occurrence of *Cetraria normerica* (*Parmelia corniculata* (Lightf.) A. L. Sm.).

—— Lichenologiska Notiser. Tom. cit. pp. 312–17 (1924).
Notes on the occurrence and distribution or biology of several species.

—— Die im Regnellschen Herbar aufbewahrten Arten der Flechtengattung *Lecanactis* (Eschw.) Wainio. Ark. Bot. XX, 2, pp. 1–6 (1926).
Three species of *Lecanactis* are recorded and described by Malme.

—— Die Pannariazeen des Regnellschen Herbars. Tom. cit. N. 3, pp. 1–23 (1926).
Five genera of Pannariaceae are included: *Parmeliella, Pannaria, Psoroma, Coccocarpia* and *Erioderma*. A number of new species are described in *Pannaria* and *Psoroma*.

—— Lichenes blasteniospori Herbarii Regnelliani. Tom. cit. N. 9, pp. 1–51 (1926).

MALTA, N. Die Kryptogamenflora der Sandsteinfelsen in Lettland. Acta Horti Bot. Univ. Latviensis, I, N. 1, pp. 13–31 (1926). German résumé, pp. 31–2.

MAMELI, EVA. Contributo alla Lichenologia del Forlivese. Atti Istit. Bot. R. Univ. Pavia e Laborat. Crittog. Ital. ser. 3, I, pp. 13–34 (1924).

MATHIESEN, FR. J. Lichenologiske Notitser. Bot. Tidssk. XXXVII, pp. 459–60 (1922).
New records for Denmark.

—— Lichens. A botanical trip to Jan Meyen by Johannes Gandrup. Dansk. Bot. Ark. IV, pp. 24–28 (1924).
Earlier collections have been described by several lichenologists. There are, however, a number of new records. They are all more or less boreal in character. Lichens and mosses formed the principal vegetation of the Island.

MERESCHOKOVSKY, CONST. Le *Parmelia camtschadalis* existe-t-il? Note dédiée à V. P. Savicz. Hedwigia, LXI, pp. 303–7 (1920).
The writer insists on the occurrence of this lichen in Kamtschatka. Savicz after an exhaustive search in Kamtschatka had arrived at the conclusion that there had been some interchange of labels between species; that it did not grow in that country.

—— Notes sur les Lichens de Revel. Bull. Soc. Bot. France, LXVII, pp. xiv–xvi (1920).
Discussion of *Ramalina fraxinea* f. *taeniata* Syd. and of *Lecanora perplexa*, recorded among the lichens of Revel.

MERRILL, G. K. New Species of American Cladoniae. Bryologist, XXVII, pp. 21–6 (1924).
Most of the new species were contributed by S. Napp from Sanford, Florida.

—— Report Canadian Arctic Expedition 1913–18, vol. IV. Botany, Part D Lichens. Ottawa, 1924, pp. 3–12.

MEYLAN, CH. Contribution à la Connaissance des Lichens du Jura. Bull. Soc. Vaud. Sci. Nat. LIV, pp. 287–94 (1922).
New localities and species for the Jura and for Switzerland.

—— Nouvelle Contribution à la Connaissance des Lichens du Jura, avec quelques Indications de Localités des Alpes. Op. cit. LVI, pp. 173–8 (1926).

—— La Flore bryologique et lichénologique du bloc erratique de la Grange-de-la-Côte. Tom. cit. pp. 165–72, 2 text-figs.

MIGULA, WALTER. Flora von Deutschland, Österreich und der Schweiz. Abt. II. Kryptogamenflora, XII, Die Flechten, Lief. 1, pp. 1– (1924).
The issue has reached to date, Feb. 1927, Lief. 20 up to p. 512 and to Family Acarosporaceae. Zahlbruckner's arrangement of families in the Pflanzenfamilien is followed. The work is enriched by plates, many of them coloured and beautifully reproduced.

MILLSPAUGH, C. F., and L. W. NUTTALL. Flora of Santa Catalina Island (California). Lichenes. Field Mus. Nat. Hist. Bot. V, pp. 358–77 (1923).
The lichens were determined by Merrill. There is a wide range of genera as well as of species represented, many of them European.

MOLISCH, HANS. *Mycoidea parasitica.* Sci. Reports Tôhoku Imp. Univ. Sendai, Japan, XII, pp. 111–15, 1 pl. (1925).

MOLLIARD, M. Lichens décorateurs d'églises. Bull. Soc. Bot. France, LXX, pp. 236–7 (1923).
Molliard in his note indicates the type of lichen most abundant on old churches in Caux. Mostly these were *Lecanora* (*Placodium*) *lobulata* and *L. atra.*

MOREAU, M., and MME FERNAND. Les Différentes Formes de la Symbiose lichénique chez le *Solorina saccata* Ach. et le *Solorina crocea* Ach. Rev. Gén. Bot. XXXIII, pp. 81–7 (1921).

—— Recherches sur quelques Lichens des Genres *Parmelia, Physcia* et *Anaptychia.* Rev. Gén. de Botanique, XXXVII, pp. 385–417, 12 figs. (1925).

MOTYKA, JOZEF. Zespoty roślin w Tatrach. Część II: Naskalne zespoty porostów nitrofilnych w polskiej części Tatr Zachodnich. Die Pflanzenassoziationen des Tatragebirges, II Teil: Die epilithischen Assoziationen der nitrophilen Flechten in Polnischen Teile der Westtatra. Bull. Acad. Pol. Sci. et Lettres, Cl. Sci. Math. et Nat. 1924, pp. 836–50, 1 pl.

—— Część VI. Studja nad zespolami Naskalnych porostów. Die Pflanzenassoziationen des Tatragebirges. VI Teil: Studien ueber epilithischen Flechtengesellschaften. Op. cit. pp. 189–227 (1926).

MOXLEY, GEORGE L. Some Vacation Lichens. Bryologist, XXIV, pp. 24–5 (1921).
List of species from the Topanga region, California.

NILSSON, GUNNAR. *Arthonia spadicea* Leight. funnen in Göteborg. Svensk Bot. Tidskr. XVII, p. 530 (1923).
Note on the above Lichen found recently at Gothenburg.

OSTERWALD, KARL. Ueber die Verbreitung der Krustenflechte *Bacidia chlorococca* in dem Florengebiet von Berlin. Verh. Bot. Ver. Prov. Brandenburg, LXV, pp. 75–8 (1923).
A species overlooked and then found to be abundant in many localities.

OXNER, A. N. Beiträge zur Flechtenflora Weissrusslands. Bull. Jard. Bot. Kieff, I, pp. 27–36 (1924). German résumé.
The author describes soil associations of lichens. One new form is described, *Parmelia perlata* f. *sorediifera.* The species were collected in Minsk and Igumen.

—— Neue und bis jetzt in der Ukraine wenig bekannte Flechten-Arten. Op. cit. II, pp. 20–8 (1925).
A list of 11 species, 10 of which are new to the Ukraine.

—— Neuheiten der Flechtenflora der Ukraine. Op. cit. III, pp. 8–21 (1925). Russian with German résumé.
The author lists 21 novelties for the Ukraine. A number of species usually sterile were found in fruit. The geographical range of several species has been extended.

—— Zur Flechtenflora Weissrusslands. Tom. cit. pp. 33–4.
The author gives a list of 8 lichens new to White Russia.

OXNER, A. N. Les Lichens du Transbaical, collectés en 1916 par G. G. Kanewskij. Ucrainian Botanical Review, III, pp. 1–10 (1926). Russian with French résumé.

The lichens were collected in 1916 on the further side of Lake Baikal. A new *Cladonia* in the group Uncialis, *Cl. Kanewskii* Oxner, has been described.

OYE, PAUL VAN. Zur Biologie von *Trentepohlia* auf Java. Hedwigia, LXIV, pp. 175–89 (1923).

PAULSON, ROBERT. Lichenes in Forbes' New Guinea Plants. Journ. Bot. LXI, Suppl. p. 64 (1923).

—— Some common Lichens. School Nature Study, XIX, pp. 54–8, with illustrations (1924).

An introduction to the study of lichens, with an account of some common species.

—— Lichenes. Shackleton-Rowett, "Quest" Expedition. Journ. Bot. LXIII, p. 70 (1925).

A list of six species: one from Gough Island, the others from Nightingale Island (Tristan da Cunha group); the latter grew on the short branches of a small shrub.

—— Lichens of Mount Everest. Tom. cit. pp. 189–93.

—— Dr H. O. Forbes' Malayan Plants. Lichenes. Op. cit. pp. 139–42 (1926).

POLYANSKIJ, VLADIMIR. De Xanthoriis in opp. Pavlovsk collectis notula. Not. Syst. Inst. Crypt. Horti Bot. Petrop. II, pp. 184–9 (1923).

Paper not seen.

PUYMALY, A. DE. Le *Chlorococcum humicola* (Naeg.) Rabenh. Revue Algologique, I, 2, pp. 107–14 (1924).

RAMSBOTTOM, J. Special Groups of Plants. B. Lichens, pp. 23–36.

Aims and Methods in the Study of Vegetation. A. G. Tansley and F. T. Chipp. Cambridge University Press, 1926.

A general account of lichens in relation (ecologically) to other groups of plants. The importance of lichens as soil-makers is emphasised.

RÄSÄNEN, VELI. Einige neue und bemerkenswerte Flechtenfunde in Finnland. Medd. Soc. Faun. et Fl. Fenn. 1919–20, pp. 156–74 (1921).

Noteworthy lichens from different districts of Finnland. A few species and varieties or forms are new to science. The new species are *Usnea prostrata* Wain., *Placodium leucoleprosum* Wain., *Physcia Wainioi* Räs., *Mycoglaena acuminans* Wain. and *Didymocyrtis consimilis*, the latter parasitic on *Placodium gilvum* and evidently an Ascomycete.

—— Die Flechtenflora des Gebiets Ostrobottnia Borealis. Suomalaisen Eläin-ja Kasitieteellisen Seuran Vanamon Julkaisuja III, N. 8, pp. 268–349 (1926).

A catalogue of species from N.E. Bothnia. Several new species are included.

—— Ueber Flechtenstandorte und Flechtenvegetationen im Westlichen Nordfinnland. Suomal, Kirjall, etc. Helsinki, pp. 190 (1927).

RIDDLE, LINCOLN W. The Lichens of the Isle of Pines. Mycologia, XV, pp. 68–88 (1923).

Interesting to students of tropical lichens as many of them are rock species. Riddle has described one new genus, *Monoblastia* (Pyrenulaceae), and 14 new species, 11 of which grow on rocks. Most of the lichens previously known from the W. Indies are corticolous.

ROBBINS, C. A. *Cladonia Beaumontii* in Massachusetts. Rhodora, XXV, pp. 46–7 (1923).

—— Some new Cladonias. Op. cit. XXVI, pp. 145–8 (1924).

The plants were collected at Wareham, Massachusetts, and were finally submitted to Wainio whose descriptions and notes are given. There is one new species, *C. clavulifera* Wain.

ROSENVINGE, L. KOLDERUP. Lichenologiske Notitser. Bot. Tidsskr. XXXVII, p. 461 (1922).
New records of *Umbilicariae*.

RYAN, HUGH, and W. M. O'RIORDAN. On the Tinctorial Constituents of some Lichens which are used as Dyes in Ireland. Proc. Roy. Irish Acad. XXXIII, Sect. B, pp. 91–104 (1917).

SAMPAIO, G. Novas contribuições para o estudo dos Liquenes portugueses. Broteria, XIX, pp. 12–35 (1921).
Seventy-four species are listed, two new to science: *Acarospora Zahlbruckneri* and *Lecanora lisbonensis*.

—— Materiais para a Liquenologia portuguesa. Op. cit. XX, fasc. 3, pp. 147–63 (1922).

—— Novas Materiais Liquenologia portuguesa. Bol. Soc. Brot. II (2 sér.), pp. 161–79 (1924).
In both papers, the lichens of Portugal are dealt with, 60 in one paper, 56 in the other. A considerable number are new to science, too numerous to list here.

—— *Carlosia*, a new Genus of Cypheliaceae. Nota appresentado ao Congresso de Salamanca.
The new genus is allied to *Cyphelia* but differs in the one-celled spores. The species, *Carlosia lusitanica*, was found on granitic rocks in Portugal.

SANDSTEDE, HEINR. Die Cladonien des Nordwestdeutschen Tieflandes und der Deutschen Nordseeinseln. III. Abh. Naturw. Ver. Bremen, XXV, pp. 89–243 (1922).
Critical review of published specimens.

SÁNTHA, L. Beiträge zur Flechtenflora der Umgebung von Kaproncka. Bot. Közlemények, XX, pp. 56–66 ([1922] 1923). Hungarian.
Paper not seen.

SAVICZ, V. P. De Peltigeraceis e Kamczatka notula. Petrograd, 10 pp. (1922). Russian with Latin résumé.

—— Note sur l'Association des Lichens et des Mousses aux Environs de la ville Augustow du Gouvernement Suwalki (Pologne). Bull. Jard. Bot. Républ. Russie, XXII, 2, Leningrad, pp. 135–41 (1923). Russian with French résumé, p. 141.
Three associations of lichens and mosses in pine forests are described: (1) on the branches of the trees, (2) on the soil, and (3) on the trunks of the trees.

—— Stereocaulacearum e Kamczatka descriptio. Notulae systematicae ex Inst. Crypt. Horti Bot. Petrop. II, N. 11, pp. 161–76 (1923). Russian with Latin résumé.
The author records a number of new forms and the discovery of *Phyllocaulon Wrightii* with apothecia; a diagnosis of the latter is given. (Better known as *Stereocaulon Wrightii* Tuck. recorded from N. Asia and Japan.)

—— De lichene, *Cetraria Richardsonii* Hook. notula. Tom. cit. N. 12, pp. 189–91.
An account of *Cetraria Richardsonii* in Russian. Synonymy and localities are added in Latin.

—— *Lichenotheca Rossica*. Op. cit. III, N. 12, pp. 1–3 (1924).
A list of 10 published species. A species and a form new to science are included and described: *Cornicularia tenuissima* f. *campestris* and *C. steppae* sp. nov.

—— (1) De *Cetraria chrysantha* Tuck. nec non *C. lacunosa* Ach. in Rossia notula, (2) De lichene terrestri novo *Cornicularia steppae* mihi nec non lichene, *Cornicularia tenuissima*. Tom. cit. N. 12, pp. 181–8 (Leningrad, 1925).

SAVICZ, V. P. Die Resultate lichenologischer Untersuchungen in Weissrussland, im Jahre 1923, 33 pp. (Minsk, 1925). Russian with German résumé.

—— Existiert *Parmelia kamtschadalis*? Eine Erwiderung an K. S. Mereschkowsky. Hedwigia, LXIV, pp. 231–2 (1924).

Savicz holds that the above species is a tropical plant. He designates the northern plant as *P. cirrhata* with two varieties: var. *americana* and var. *oceano-asiatica*, the latter occurring in Kamtschatka.

—— Lichenotheca Rossica. Notulae Syst. Inst. Crypt. Horti Bot. Princip. U.S.S.R. IV, N. 3, pp. 34–7 (1926).

A second instalment of 10 numbers. One new species is described: *Cetraria libertina* E. Stuckb.

—— Flechten aus Tobolsk (Sibirien) gesammelt von B. M. Gorodkov im Jahre 1915. Travaux Musée Bot. Acad. Sci. de l'U.S.S.R. pp. 87–106 (1926). Russian with German résumé.

Previous collections by Gorodkov in the neighbourhood of Berezow gave a considerable list of species. This further study adds a number of species, one new to science: *Pertusaria stalactizoides*.

SAVICZ, V. P., and L. J. SAVICZ. Kurzer vorläufiger Bericht über die Erforschung der Moos- und Flechten-Flora Weissrusslands im Sommer, 1923, 16 pp. (Minsk, 1924). Russian with German résumé.

In this first paper a sketch is appended in German of the various associations of mosses and lichens determined by the authors.

SERVIT, M. Dvě československé lokality lišejníku *Belonia russula* Koerb. Časopis Národního Musea, Prag, p. 139 (1925).

Two new localities for the lichen *Belonia russula* in Czecho-Slovakia. See also Hedwigia, LXVI, Beiblatt, p. 74 (1926).

It is noted that the spores measure 80–90μ long.

SMITH, A. LORRAIN. Lichen Dyes. Trans. Brit. Mycol. Soc. XI, pp. 45–50 (1926).

An account of lichen-dyeing industries, the composition and occurrence of the dye-acids and the methods of collecting and preparing the dye-lichens.

—— Cryptotheciaceae. A Family of Primitive Lichens. Tom. cit. pp. 189–96, 1 pl.

—— A Monograph of British Lichens. Part II, ed. 2. Printed by Order of the Trustees of the British Museum, 447 pp., 63 pls. (1926).

SMITH, A. LORRAIN, and M. C. KNOWLES. Lichens of the Dublin Foray. Trans. Brit. Mycol. Soc. XI, pp. 18–22 (1926).

The conditions and the types of lichen vegetation in the various districts are described. Altogether 191 species and varieties were identified; several were new to Ireland.

SOMMIER, S. Flora dell' isola di Pantelleria. Firenze, Ricci, 110 pp. (1922). See Bull. Soc. Bot. Fr. LXXI, p. 1251 (1924).

A list with critical notes of cryptogams, of which 47 are lichens.

STEINER, J. Wissenschaftl. Ergeb. der Exp. nach Mesopotamien, 1910: Lichenes aus Mesopotamien und Kurdistan sowie Syrien und Prinkipo. Ann. Naturhist. Mus. Wien, XXXIV, pp. 1–68 (1921).

The lichens enumerated belong mostly to well-known European genera; many of the species are new; the large majority are saxicolous. The paper was prepared before the lamented death of the author and has been issued by A. Zahlbruckner.

STUCKENBERG, ELISABETH. Recherches sur les Cladonies des Gouv. de Penza et de Saratow. Russia, Penza, pp. 1–69 (1917). Short French résumé.

The author gives a critical account of 24 species (51 varieties and forms).

—— Lichenis novi *Cetraria libertina* mihi descriptio. Notulae Syst. Inst. Crypt. Horti Bot. Princip. U.S.S.R. IV, N. 3, pp. 31–4. Russian with Latin diagnosis.

The new species resembles *Cetraria islandica* but differs in bearing branched cilia and isidia.

SUMMERHAYES, V. S., and C. S. ELTON. Contributions to the Ecology of Spitsbergen and Bear Island. Journ. Ecology, XI, pp. 214–86, 3 pls., 7 figs. (1923).
A considerable number of lichens are included in the various plant associations, especially those on soil and on rock.

SUZA, JINDRICH. Lichenes Slovakiae. I. Acta Bot. Bohemica, I, pp. 25–39 (1923). A first instalment.

—— Lichenes Slovakiae. II. Op. cit. IV–V, pp. 3–20 (1925–6).
The lichens were collected in the Carpathian mountains in Slovakian territory. Localities, habitats, etc. are recorded in Latin.

—— Sketch of the Distribution of Lichens in Moravia with regard to the conditions in Europe (with English Summary). Publ. Facul. Sci. Univ. Masaryk, 152 pp., 10 figs. (1925).
"A phytogeographical comparative study."

—— Lišejníky Podkarpatské Rusi. Die Flechten Karpathorusslands. (Slovakian with German résumé.) Zvl. otisk Sborn. Přírodov. společ. Mor. Ostravě, III, pp. 1–18 (1924–5).
The lichens enumerated are from sandstone, moss cushions, etc., a less conspicuous flora than on the granite or limestone of the high Tatra. In the virgin forests large foliose Parmeliae and Cetrariae were collected, and in moist situations *Usnea longissima, Alectoria thrausta, Parmelia sinuosa*, etc.

—— Notes sur la flore épiphytique des lichens des chênaies près de Terešva (Russie Subcarpathique) (French résumé). Op. cit. VII, pp. 1–4 (1925).
Notes on the oaks of great size and age, part of the virgin forest near the frontier of Czechoslovakia and Roumania. The epiphytic lichen flora is described. Over 60 lichens are listed.

—— Lišejníky Československých Karpat. Les Lichens des Carpathes Tchécoslovaques (French résumé). Op. cit. VIII, pp. 1–16 (1925).
The list deals only with the larger lichens, including a number of Cladoniae; *Dufourea madreporiformis* is recorded from lime soils in the highest regions of the Tatras.

TAGDELL, ALFRED J. Mount Bagong and its Flora. Victorian Naturalist, XLI, pp. 56–80 (1924).
A few lichens are included from heights of about 6000 ft. The mountain is formed of gneiss.

TIMKÓ, GYORGY. Beiträge zur Flechtenflora von Polen. Bot. Közlemén. XIX, pp. 84–8 (1920–21). Hungarian with German résumé.

—— Új adatok a Budai és Szentendre (Neue Beiträge zur Kenntniss der Flechtenvegetation des Buda-Szentendré-Visegráder Gebirges. Op. cit. XXII, pp. 81–104 (1925). Hungarian with German résumé.
The locality is described and 250 species listed.

TOBLER, F. Vorkommen und Abbau von Flechtenstärke. Ber. Deutsch. Bot. Ges. XLI, pp. 406–9 (1923).

—— Biologie der Flechten. Gebrüder Borntraeger, Berlin, pp. viii–266, 1 col. pl., 67 figs. (1925).

—— Zur Physiologie der Farbunterschiede bei Xanthoria. Ber. Deutsch. Bot. Ges. XLIII, pp. 301–5 (1925).

TOMIN, M. P. Les Formes oecologiques intéressantes de quelques lichens fruticuleux, rencontrées dans le gouvernement de Smolensk. Mém. Inst. Agron. Voronèje, III, pp. 46–54, 1 pl. (1918). French résumé.

—— Matériaux pour la Flore des Lichens du Gouvernement de Smolensk. Tom. cit. pp. 105–28, 1 pl. French résumé.
A list of lichens collected by the author. Two new species and one form were discovered and described.

TOMIN, M. P. De forma nova Rinodinae nimbosae (El. Fr.) Th. Fr. form. sareptana Tomin. Notulae Systematicae ex Inst. Crypt. Horti Bot. Petrop. pp. 78–80 (1923).

A form distinguished by the caesio-pruinose apothecia without thalline margins. Collected in Sarepta, province Tsaritsyn.

—— De *Buellia* nova in Russia Media inventa. Tom. cit. pp. 139–40.

The new lichen *Buellia Elenkini* was found on birch trees. Thallus granular-leprose with a black limiting hypothallus; spores 1–4 septate and sometimes muriform, 22–28μ × 8–13μ.

—— Beiträge zur Lichenen-Flora des Gouvernements Woronesh. Russian with German résumé. Woronesh, 14 pp. (? 1926).

Tomin has examined a number of collections and records 145 species and forms. There is one new to science, *Dermatocarpon subcinereum*.

—— Neue Flechten aus Süd-Ost. Russland. Russian with German résumé. Woronesh, 8 pp. (1926).

The lichens were collected in the Gouvern. Astrachan. Several new species are described.

—— Enumeratio Licheninir Austro-Ussuriensium. Bull. Southern Ussuri Branch State Rus. Geogr. Soc. Russian, N. 12, pp. 211–24 (1926).

A record of 85 species including several new to science: *Placodium Gordejevi*, *Anaptychia isidiata* and *Pyxine sibirica*.

TRÜMPENER, EGON. Ueber die Bedeutung des Wasserstoffionenkonzentration für die Verbreitung von Flechten. Beih. Bot. Centralbl. XLII, 3, pp. 321–54 (1926).

UPHOFF, T. C. TH. The Occurrence of Purple Bacteria as Symbionts of a Lichen. Amer. Journ. Bot. XII, pp. 97–103, 1 fig. (1925).

VAINIO, E. A. Lichenes in summo monte Doi Sutep (circa 1675 ms.) in Siam boreali anno 1904 a C. C. Hosseo collecti. Ann. Soc. Zool. Bot. Fenn. Vanamo, I, pp. 33–55 (1923).

Many of the species are new to science, nearly all those listed are corticolous.

—— Lichenes in Insula Trinidad a Professore R. Thaxter collecti. Proc. Americ. Acad. Arts and Sci. LVIII, 131–47 (1923).

A list of 64 species from the W. Indies. Many of them are new to science. The majority are small crustaceous species.

—— Lichenes Teneriffenses. Mém. Acad. Roy. Sci. et Lettres Danemark, sér. 8, VI, pp. 392–3 (1924).

Lichens collected by Börgesen during an expedition to the Canary Islands. *Roccella Boergesenii* is new to science. The species are mostly European and common in temperate countries.

—— Lichenes A. W. A. Setchell et H. E. Parks in Insula Tahiti a 1922 collecti. Univ. Calif. Publ. Botany, XII, N. 1, pp. 1–15 (1924).

Most of the species are new to science.

—— Lichenes Tahitensis. Univ. Calif. Publ. Bot. XII, pp. 1–16 (1924).

Many of the species described are new to science.

—— Lichenes Mexicani a F. M. Liebmann annis 1841–43 collecti, in Museum Hauniensi asservati. Dansk. Bot. Ark. IV, N. 11, 25 pp. (1926).

An old collection from the neighbourhood of Orizaba now described. The list includes many new species.

—— Lichenographia Fennica. I. Pyrenolichenes usque proximi Pyrenomycetes et Lichenes Imperfecti. Acta Soc. Faun. et Fl. Fenn. XLIX, pp. 1–274 (1921).

—— Lichenographia Fennica. II. Baeomyceae et Lecideales. Op. cit. LIII, pp. 1–340 (1922).

WATSON, W. Lichenological Notes. I. Journ. Bot. LXIII, pp. 130–2 (1925).

Two new species are recorded: *Stenocybe bryophila* on stems of hepatics and *Clathroporina calcarea*, the latter a tropical genus and species new to Britain.

WATSON, W. Lichenological Notes. II. Op. cit. LXV, pp. 109–13 (1927).

—— The Bryophytes and Lichens of Arctic-Alpine Vegetation. Journ. Ecology, XIII, pp. 1–25 (1925).

WERNER, R. G. *Xanthoria parietina* lichen, son champignon en culture pure. Bull. Soc. Mycol. France, XLI, pp. 585–7, 1 pl. (1923).

WYSSOLZKY, G. N., L. I. SAVICZ und V. P. SAVICZ. Durch das südliche Weissrussland. Beobachtung während der botanischen Excursionen. (Russian with German résumé.) 51 pp. Minsk, 1925.
A considerable number of lichens were collected and determined by V. P. Savicz.

YASUDA, A. Die Flechten Japans. Sendai, 1925, pp. 118, tab. 24. See Ann. Mycol. XXV, p. 191 (1927).

ZAHLBRUCKNER, A. Ueber die Sexualität der Flechten. Verh. Zool. Bot. Gesell. Wien, LXXIII, pp. 48–9 (1924).
Notes of a discussion on sexuality in lichens.

—— Die Flechten der Osterinsel, nebst einem Nachtrag zu der Flechtenflora von Juan Fernandez. Nat. Hist. of Juan Fernandez and Easter Island by Dr Carl Skottsberg, II, pp. 449–60 (1926).

—— Catalogus Lichenum Universalis. Leipzig, Borntraeger, I, 696 pp. (1922); II, 815 pp. (1924); III, 899 pp. (1925).

—— Chilenische Flechten gesammelt von C. Skottsberg. Göteborgs Botaniska Trädgård, II, pp. 1–26 (1925–6).

—— Afrikanische Flechten (Lichenes). Engler, Botanische Jahrbücher, LX, pp. 469–552 (1926).

—— Beiträge zur Flechtenflora Niederösterreichs. Verh. Zool. Bot. Gesell. Wien, LXXVI, pp. 76–98 (1926).

—— Spiegazione delle Tavole Lichenologiche inedite di Abramo Massalongo. Estratto del volume giubilare "Abramo Massalongo, 1824–1924." Verona, 1926. 9 coloured plates of lichens.

—— Lichenes (Spezieller Teil). Engler und Prantl, Die Natürlichen Pflanzenfamilien, VIII (Zweite Auflage), pp. 61–270, 127 figs. (1926).

ZEDROSSER, TH. Die Flechten des Lavanttales. Carinthia, II. Mitt. Naturhist. Landesmus. Karnten, 34 and 35, pp. 29, 38. Klagenfurt (1925). See Hedwigia, LXVI, Beiblatt, p. 101 (1926).

ZIEGENSPECK, H. Ueber Jod unter Blaufärbung-Stoffe in den Asci von Flechten. Ber. Deutsch. Bot. Ges. XLII, pp. 116–19 (1924).

ZSCHACKE, HERMANN. Die mitteleuropäischen Verrucariaceen. I. Hedwigia, LIV, pp. 183–98, 1 pl. (1914). II. Op. cit. LV, pp. 286–34, 3 pls. (1914). IV. Op. cit. LXV, pp. 46–64 (1924).

—— Die Flechten des Davoser Tales. Mittel. Naturf. Ges. Davos, 59 pp. (1925–6).
A large collection of lichens made by Zschacke during internment at Davos. He lists them first according to substratum and follows with a classified account.

SEPTOBASIDIUM RAMEALE.

(With Plates XVIII and XIX.)

By T. Petch, B.A., B.Sc.

In *The Fungi of Ceylon*, No. 605 (1873), Berkeley and Broome described *Lachnocladium rameale* B. & Br., "Atropurpureum filiforme furcatum, apicibus acutis, basi setis tenuibus mixtum; mycelio tenuissimo albo (No. 595). On living branches; running up the petioles of the leaves, and sometimes on the leaves themselves. Ambagamowa, Sept. 1862." We will refer to this as species *A*, in the hope that the following account will thereby be the more intelligible. The fungus consists of a number of stout, erect, close-set bristles, which present a surface resembling that of a hair brush. Sometimes it completely surrounds a stem, and then it has the appearance of a bottle brush, or a pipe cleaner (Plate XVIII, figs. 4, 5).

In *The Fungi of Ceylon*, No. 611 (1873), Berkeley and Broome described *Hymenochaete ramealis* Berk., "Ambiens, coffeicolor, confluens, margine late reflexo, extus zonata strigosa. On branches of living shrubs. Nuwara Eliya, Jan. 1847. Running down the stems for several inches; margin on either side broadly reflexed." The species was attributed to Berkeley, instead of Berkeley and Broome, apparently because Berkeley had had the specimen in hand since 1847, it being one of the fungi sent by Gardner. Cooke, in *Grevillea*, VIII, p. 150 (1880), stated that the type specimens resembled *Hymenochaete* in habit but were without setae. Massee, in his *Monograph of the Thelephoreae*, pt 2, p. 187 (1890), transferred this species to *Stereum*, repeating Berkeley's description with the addition "hymenio glabro; sporae subglobosae, 5μ." We will refer to this as species *B* (Plate XIX, fig. 1).

In *The Fungi of Ceylon*, No. 575, Berkeley and Broome had described *Thelephora suffulta* B. & Br., and added the note: "The same species was sent by Gardner on living shrubs from Ramboda, Jan. 1847, but with the supporting hairs scattered." In Herb. Kew., there is the type of *Thelephora suffulta* (Thwaites 669), another specimen, Thwaites 152, and in the same cover, Gardner's specimen from Ramboda, January 1847. The three fungi are all different species, the Ramboda specimen being *Hymenochaete ramealis*, species *B*. The two Kew specimens of species *B*, under *Hymenochaete ramealis* and *Thelephora suffulta* respectively, were collected by Gardner in the same month and in the same neighbourhood. Ramboda is the name of the pass

leading up to Nuwara Eliya. Thwaites 152 is apparently not *Septobasidium*, but an immature Dematiae, probably *Graphium*.

In *Grevillea*, XIX, p. 108 (1891), Cooke stated that *Thelephora suffulta* B. & Br. was only a form of *Thelephora pedicellata* Schw., but he did not state on which of the Ceylon specimens in the cover of *Thelephora suffulta* he had based his decision. It would appear quite impossible that it could have been based on Thwaites 669, the type of *Thelephora suffulta*. Patouillard, *Bull. Soc. Myc. France*, XXIV, p. 2 (1908), referred *Thelephora suffulta* B. & Br. to *Septobasidium*, and the true *Thelephora suffulta* does not come further into this discussion.

In *Annals of Botany*, XXV, p. 843 (1911), the writer, in a note on the biology of the genus *Septobasidium*, referred to *Lachnocladium rameale* B. & Br. as a *Septobasidium*, without, however, actually employing the combination *Septobasidium rameale*. This reference was to species *A*.

Bresadola (*ante* 1915) examined the specimens of Basidiomycetae in the Kew herbarium, and made notes on the herbarium sheets. Under *Lachnocladium rameale* (species *A*), he noted: "Ce n'est pas un *Lachnocladium*, mais l'état avortif d'un *Septobasidium* que je crois d'avoir de Philippines et que je dénommerais *Septobasidium rameale* (B. & Br.)." He added a portion of the Philippine specimen to the herbarium sheet, and that specimen is species *B*.

Under *Thelephora suffulta*, Bresadola attached to the specimen, species *B*, Gardner, Ramboda, Jan. 1847, the note, "hoc specimen diversum et potius ad *Septobasidium rameale* ducendum."

Hence Bresadola named his Philippine specimen, *Septobasidium rameale*, on the supposition that it was the same species as *Lachnocladium rameale* B. & Br., species *A*, which it is not. But at the same time he correctly referred to his Philippine species, Gardner, Ramboda, 1847, which is species *B*, *Hymenochaete ramealis* Berk. Therefore, although Bresadola's reason for choosing the name *Septobasidium rameale* was wrong, the name would still have been the correct one for his species (with the substitution of Berk. for B. & Br.), if the combination had not been previously applied to a different species. For the purist in nomenclature, this raises the question whether the statement in *Annals of Botany*, XXV, p. 843 (1911), was effective publication.

Lloyd, in *Mycological Notes*, No. 61 (1919), described and figured *Septobasidium rameale* from the type of *Lachnocladium rameale* B. & Br., *i.e.*, species *A*. At the same time he described a new species, *Septobasidium alatum*, from the Philippines, and stated that his species was based on Macgregor 20385, which had been misreferred to *Septobasidium rameale*. His description

states that *Septobasidium alatum* has no hyphal pillars, and that the basidia are hyaline, cylindric, septate, and curved.

In *Ann. Myc.* XX, p. 66 (1922), Sydow stated that *Septobasidium alatum* Lloyd, according to the description and figure, and his examination of the original specimen, was identical with *Septobasidium granulosum* Syd. in Engler's *Bot. Jahrb.* Bd. LIV (1916), p. 253. Herr H. Sydow has kindly furnished me with a specimen of *Septobasidium granulosum*, and it proves to be quite different from *Lachnocladium rameale* B. & Br. (species *A*) and *Hymenochaete ramealis* Berk. (species *B*). It agrees with the latter in having a free projecting margin, but it has no hyphal pillars. The intermediate layer consists of loosely interwoven hyphae, while the hymenial layer is peculiar in being formed by separate tufts of hyphae arising from the intermediate layer and closely packed side by side to present a continuous surface (Plate XVIII, fig. 3).

Apart from the foregoing error, misunderstanding has arisen through Berkeley and Broome's use of the same specific name for two different fungi, both of which are now recognised to be *Septobasidium*. Bresadola's species from the Philippines is not identical with *Septobasidium rameale* (B. & Br.) = *Lachnocladium rameale* B. & Br. (species *A*), as he thought; but it is identical with *Septobasidium rameale* (Berk.) = *Hymenochaete ramealis* Berk. (species *B*).

Patouillard, in *Bull. Soc. Myc. France*, XXXVI, p. 175 (1920), redescribed *Lachnocladium rameale* B. & Br. as *Septobasidium rameale* (B. & Br.) Petch (non *Hymenochaete ramealis* Berk.). He recorded it on branches of living trees, attacked by coccids, in Annam and Tonkin. His description and notes are:

"Très rarement fructifié. Les probasides naissent isolément sur les hyphes de la périphérie ou à leur extrémité; ce sont des vésicules globuleuses (15μ de diam.), ou ovoïdes allongées (50 × 10μ), incolores ou brunâtres, à parois minces.

"Cette plante ne doit pas être confondue avec *Hymenochaete ramealis* B. & Br., qui est *Septobasidium rameale* Bres. (non Petch), et aussi *S. alatum* Lloyd, *Mycol. Notes*, No. 61, p. 888, espèce d'abord entièrement résupinée devenant avec l'âge plus ou moins réfléchie et presque dimidiée, dont les probasides ovoïdes (12–15μ) donnent naissance à des basides triseptées, droites ou courbées."

As we have already seen, *Septobasidium alatum* Lloyd (*granulosum* Syd.) must be deleted from the synonymy of both species *A* and species *B*.

Subsequently, Patouillard found that species *A* had been named several years before it was described by Berkeley and Broome. It was described and figured in 1834 by Montagne in

the section on fungi in Belanger, *Voyage aux Indes Orientales, pendant les années* 1825–1829, from specimens collected in Southern India, under the name *Hydnum? pteruloides* Mont. The original specimens, which are still in Herb. Montagne, were examined by Patouillard, who found that they were the same as *Lachnocladium rameale* Berk. Patouillard published the name *Septobasidium pteruloides* (Mont.) Pat. in *Bull. Soc. Myc. France*, XLI, p. 337 (1925).

Species *A* thus becomes *Septobasidium pteruloides* (Mont.) Pat. (1925); *Hydnum? pteruloides* Mont. (1834); *Lachnocladium rameale* B. & Br., *Journ. Linn. Soc.* XIV, p. 67 (1873); *Septobasidium rameale* (B. & Br.) Petch, *Ann. Bot.* XXV, p. 843 (1911) and in Patouillard, *Bull. Soc. Myc. France*, XXXVI, p. 175 (1920); non *Septobasidium rameale* (B. & Br.) Bres. in Herb. Kew.

Whether the name *Septobasidium rameale* can now be employed for species *B* will depend on the code followed by the individual mycologist. In view of the confusion attendant on the use of that name, it would seem preferable to rename species *B*, and I would accordingly name it *Septobasidium aligerum*. Its synonymy is

Septobasidium aligerum Petch; *Hymenochaete ramealis* Berk., *Journ. Linn. Soc.* XIV, p. 68 (1873); *Stereum rameale* (Berk.) Massee, *Journ. Linn. Soc.* XXVII, p. 187 (1890); *Septobasidium rameale* Bres. in Herb. Kew.; *Septobasidium rameale* (Berk.) Bres. in Petch, *Trans. Brit. Myc. Soc.* VII, p. 34 (1921).

Septobasidium pteruloides (Mont.) Pat.

This species has been found on comparatively few occasions in Ceylon, at Hakgala (5600 ft.) and Nuwara Eliya (6200 ft.). It grows over colonies of scale insects on branches up to a centimetre in diameter, along which it may run for a length of about six inches, completely surrounding the branch. In colour it is violet or purple-black when fresh, with a narrow white margin. The basal layer is thin, and composed of repent purple-brown hyphae, more or less parallel to one another; towards the margin many of the hyphae are arranged in fascicles and some are hyaline. Another thin layer is formed over the basal layer, not continuously, but leaving oval gaps, up to 2 mm. long and 0·5 mm. wide; and from the edges of these gaps there arise erect bristles, which are consequently arranged in rings. These rings are best seen towards the margin of the stroma where the bristles are in the early stages of development (Plate XIX, fig. 4). A little distance back from the margin the bristles are 30–50μ diameter at the base, tapering upwards to a point; they are erect fascicles of more or less parallel hyphae, with a few free hyphal ends spreading out at a wide angle. These bristles

grow until they attain a height of about 6–10 mm. Several of them, up to half a dozen, may fuse together to form these larger "clavae," which may be 0·5 mm. in diameter. These clavae are generally simple with acute tips, but they may be forked at any height, or the apex may consist of a cluster of points, as though the original constituent bristles had separated again there.

Most of the available specimens of this species are sterile. In one collection, however, Hakgala, April 1919, the clavae bear probasidia scattered along their whole length. In this specimen, the clavae had lost their purple-black colour, and were pale purple-brown when fresh and greyish when dry; in some instances they were up to 10 mm. high, and rather loose above, and had fallen together laterally so that they resemble a tuft of *Stemonitis* (Plate XIX, fig. 3).

The clavae are composed entirely of longitudinal hyphae. The probasidia are situated laterally or terminally on the outer hyphae, either scattered, or in small groups; they are thin-walled, globose, 8–10μ diameter, or pyriform, up to 15 × 10μ. Basidia and spores have not been observed.

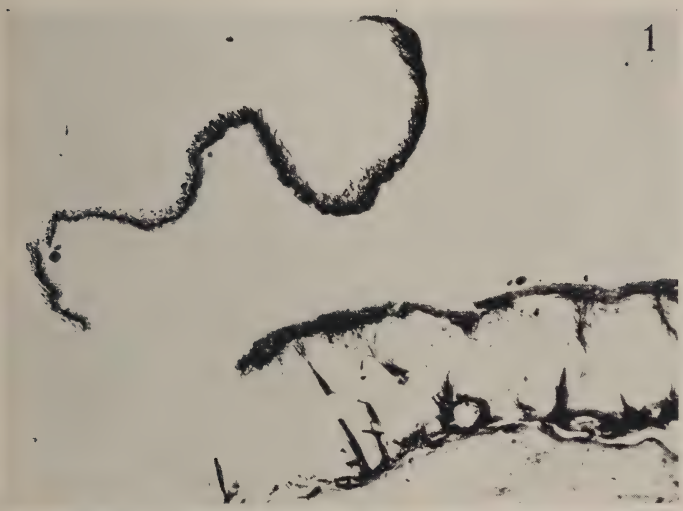
The most remarkable feature of this species is that it does not form an "upper deck," *i.e.* a hymenial layer uniting the apices of the bristles and supported by them. Instead, the bristles develop into clavae which bear the hymenium along their whole length.

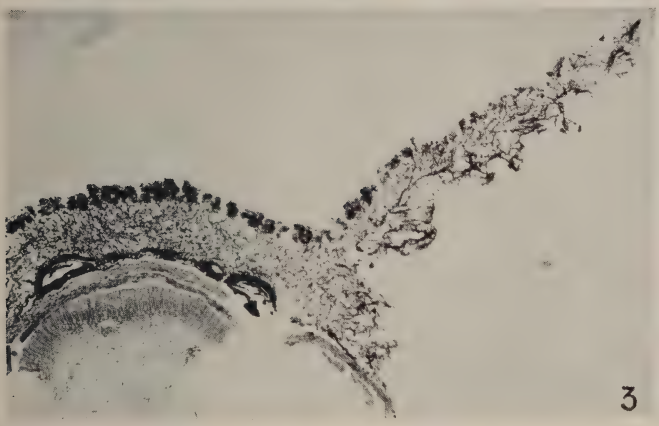
Septobasidium aligerum Petch.

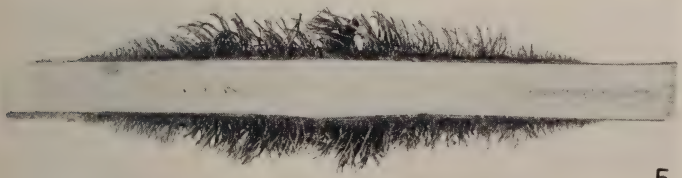
Septobasidium aligerum is a common species "up-country" in Ceylon, descending to about 4000 ft. It is found on shrubs in the jungle, overrunning stems and leaves, and frequently occurs in gardens on orange trees infested by scale insects. On the latter, it may cover all the branches for almost their whole length.

The basal layer is a thin resupinate film, 40–60μ thick, purple or purple-black in colour. From this layer arise slender black or black-brown bristles up to 1·25 mm. high, which are rigid, erect fascicles of hyphae, 0·05 mm. in diameter at the base, tapering upwards. These bristles are scattered in no particular order, about 0·1–0·2 mm. apart (Plate XIX, fig. 2).

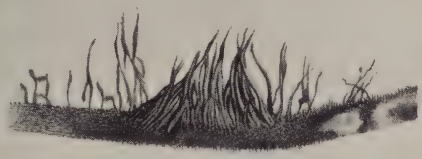
From the apices of these bristles, the hyphae spread out laterally in a small, more or less circular disc, and these discs unite, so that a continuous upper layer is formed, supported by the bristles. When fully developed this upper layer is 0·1–0·15 mm. thick, and purple-grey. The outer surface of this is the hymenial layer. In the natural position of the fungus this surface faces downwards. The basal layer with its forest

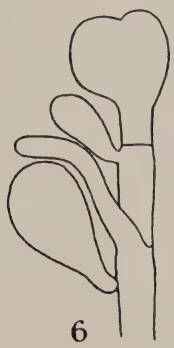






SEPTOBASIDIUM





SEPTOBASIDIUM

of bristles usually extends beyond the upper layer (Plate XIX, fig. 1).

The foregoing method of development is common to many species of *Septobasidium*. *Septobasidium aligerum*, however, in its further development, shows a peculiarity which appears to occur in few other species. When growing along a branch, the formation of the upper layer begins on the bristles on the lower surface of the branch. When this has extended about half way round the branch, it may be continued up the sides and over the upper surface of the branch, as in other species of *Septobasidium*, but, perhaps more generally that does not happen. Instead, the upper layer grows out from the sides of the branch as a free pileus, up to a centimetre broad. As the fungus usually grows on small branches, it nearly always forms this free pileus. The habit is similar to that of *Hymenochaete tenuissima*.

The upper surface of the free pileus is radially strigose with coarse fascicles of hyphae, and frequently zoned parallel to the margin. As a rule, it is readily seen that the pileus is continuous with a resupinate part supported by bristles. Sometimes, however, the hinder margin of the pileus fuses with the basal layer, so that the bristles are hidden from view; and in old specimens the bristles beneath the resupinate part may collapse or may be hidden by a further growth of hyphae from the basal layer. This appears to have been the case with the type specimen of *Hymenochaete rameale* Berk., which is an old, weather-worn specimen. In some cases, the bristles project through the hymenium. These bristles are present in the type specimen of *Hymenochaete ramealis*, chiefly on the basal layer above the reflexed pilei; and, from Berkeley's reference of that specimen to *Hymenochaete*, it would appear probable that he saw them. When old, the fungus becomes purple-brown or rufous brown. Probasidia have not been observed.

This is the species distributed at the Minehead Foray (1920) as *Septobasidium rameale*, and referred to in *Trans. British Myc. Soc.* VII, p. 34, as *Septobasidium rameale* (Berk.) Bres.

EXPLANATION OF PLATES.

Plate XVIII.

Fig. 1. *Septobasidium aligerum*. Section. × 20. This is from an old herbarium specimen; the pillars are broken, and the wing detached.

Fig. 2. *S. aligerum*. Section showing an unbroken pillar. × 20.

Fig. 3. *S. granulosum*. Section. × 20. The cavities at the base of the fungus indicate the positions of the host insects.

Fig. 4. *S. pteruloides*. × $\frac{3}{4}$.

Fig. 5. *S. pteruloides*. Longitudinal section of the specimen of Fig. 4. × $\frac{3}{4}$.

PLATE XIX.

Fig. 1. *Septobasidium aligerum.* Natural size.

Fig. 2. *S. aligerum.* Longitudinal section of the host branch, showing advancing edge of stroma. × 8.

Fig. 3. *S. pteruloides.* A cluster of clavae bearing probasidia. Natural size.

Fig. 4. *S. pteruloides.* Advancing edge of stroma. × 6.

Figs. 5–7. *S. pteruloides.* Developing probasidia. × 1200.

THE INFLUENCE OF ENVIRONMENT ON THE INFECTION BY LIGNIERA JUNCI.

By W. R. Ivimey Cook, B.Sc.

IN a recent paper (4) reference was made to an observation of Schwartz (7) concerning the peculiar habitat of five species of *Ligniera* which he described. Examination of water plants from various similar habitats over the south of England has shown that *Ligniera* occurs in other parts of the country, but nowhere has it been found so abundantly as in the neighbourhood of Knole Park, Sevenoaks, Kent. It would seem, therefore, that there is something about the locality which is particularly favourable for the development of the fungus.

Cross-inoculation experiments (4) have shown that so far only one species of *Ligniera* is known to occur in this country and it is therefore assumed that the various records from other localities in Southern England refer to the same species, *Ligniera Junci.*

In the spring of 1926 an attempt was made to determine what physiological factors favoured the growth of the fungus.

At the present time much importance is attached to the hydrogen ion concentration of the soil or water in which plants are growing, and a determination of the acidity of the water in the pond was therefore made. It was found to be slightly acid, *p*H 5·5. It was also noticed that there was an excess of iron in the water, and it was thought that these two factors might be of importance in explaining the abundance of the fungus in this particular locality. Accordingly during the spring of that year experiments were set up to test these points.

METHODS.

Three series of experiments were finally used, although attempts were made to carry out a fourth series. In Series I thirty plants were used, in Series II, sixteen, and in Series III, fifteen plants. The plants were grown in flat, open glass jars

about 12 cm. in diameter and 5 cm. deep, with a capacity of slightly over 250 c.c. *Callitriche stagnalis* and *Ranunculus aquatilis* were found most suitable for the experiments. In the fourth series an attempt was made to use *Ranunculus circinatus*, but the conditions under which the cultures were grown did not favour the growth of this plant and the series was later discarded.

Two hundred cubic centimetres of Sachs' Culture Solution were placed in each jar, and; in Series II, about half an inch of sterilised silver sand was added to cover the roots of the plants. Iron, in the form of ferric chloride, was added in excess of what is normally used in this culture solution, about 2 c.c. of a ten per cent. solution being used.

In Series I, plants of *Callitriche stagnalis* were collected from one of the ponds at Knole Park, and roots examined before the cultures were set up were found to be heavily infected with *Ligniera Junci*. A quantity of infected material was also kept in a large bell jar, with soil at the bottom, and at the end of the experiments the roots were still found to be infected.

In Series II the plants of *Ranunculus aquatilis* were collected at Beckenham, Kent, from a pond in which *Ligniera Junci* has not been found. They were planted in the same way as those in Series I, except that the roots were immersed in silver sand which had been autoclaved twice for several hours at a temperature of 110° C. to ensure its being free from infection. Control material from the same pond was kept in the greenhouse throughout the experiments and at the end was found to be still free from disease.

Series III resembled Series I in all respects except that the material used was free from the fungus. It was collected from the same pond at Beckenham as the *Ranunculus aquatilis*. Control plants were also grown in a bell jar in their native soil and remained free from infection throughout the summer.

Twenty-four hours after a culture had been set up the *p*H value of the solution was determined. 5 c.c. of the culture solution was tested with Universal Indicator. The *p*H values selected were purely arbitrary. It was desired to have one set of plants growing in distinctly acid solution, and for these a *p*H of 5 was used, others in a strongly alkaline solution, at about *p*H 10, while a third set should be maintained at about *p*H 7, or as near neutrality as possible. The method used was thus somewhat crude. The continual change which took place in the composition of the culture solution due to the action of the plants and the gradual absorption of carbon dioxide from the air, caused considerable alteration in the *p*H value after the culture had been set up. The relative acidity or alkalinity was, therefore, tested each week and the value brought back by

the addition of either acid or alkali. On the whole there was a general tendency for all cultures to become more alkaline.

After a culture had been growing for from seven to eight weeks, each plant in Series II and III was inoculated with infected material by planting in the jar diseased plants of *Callitriche stagnalis* in Series II, and *Ranunculus aquatilis* in Series III.

In the course of cross-inoculation work which had been carried out previously it was found that the disease can be contracted in about fourteen days. The plants in Series II and III were allowed to continue growing for from three to four weeks; at the end of that time the plants used for infection were removed and the culture plants in all the series were collected and preserved separately in alcohol for examination.

The experiments were carried out in the roof greenhouses at King's College, London. These houses are very exposed, and despite very great care in shading the plants at all times with green shading, and during sunny weather with additional brown shades just above the jars, the temperature rose as high as 105° F. As a result of this the leaves, particularly those of *Ranunculus aquatilis*, became brown and sometimes slightly withered. This, however, did not seem to affect the actual growth and vigour of the plants which appeared as healthy as those grown in large bell jars under as far as possible normal conditions.

There was a considerable loss of water in the jars due to evaporation, but this loss was made up daily by the addition of distilled water, which was prepared in the department using only glass apparatus, in order to prevent the introduction of any copper or other minerals, which might be deleterious to the zoospores of *Ligniera Junci*.

Results.

Table I. *Infected plants of* Callitriche stagnalis *grown in three series of jars at different* pH *values. Planted March 25th, examined July 3rd.*

Plant No.	Mean pH value obs.	Infection obs.	Plant No.	Mean pH value obs.	Infection obs.	Plant No.	Mean pH value obs.	Infection obs.
A. 1	6	—	A. 11	7	—	A. 21	10	—
A. 2	6	—	A. 12	7	+	A. 22	10	—
A. 3	5	—	A. 13	7	—	A. 23	10	—
A. 4	5	—	A. 14	7	—	A. 24	10	—
A. 5	5	—	A. 15	7	—	A. 25	9	—
A. 6	5	—	A. 16	8	—	A. 26	10	—
A. 7	5	—	A. 17	7	—	A. 27	10	—
A. 8	5	slight	A. 18	7	—	A. 28	10	—
A. 9	5	—	A. 19	7	—	A. 29	10	—
A. 10	5	—	A. 20	7	—	A. 30	10	—

In this culture the roots were exposed and some developed chloroplasts like the stem and leaves.

Table II. *Plants of* Ranunculus aquatilis *grown in three series of jars at different pH values, and inoculated with diseased roots of* Callitriche stagnalis. *Planted April 14th, inoculated June 14th, examined July 3rd.*

Plant No.	Mean *p*H value obs.	Infection obs.	Plant No.	Mean *p*H value obs.	Infection obs.	Plant No.	Mean *p*H value obs.	Infection obs.
B. 1	6	+	B. 12	8	—	B. 21	10	—
B. 2	6	+	B. 14	8	+	B. 23	10	—
B. 7	6	+	B. 18	7	+	B. 26	10	—
B. 10	6	+	B. 35	8	+	B. 29	10	—
B. 31	7	+	B. 36	8	+	B. 30	9	—
B. 33	7	+						

In this culture the roots were buried in silver sand which had been sterilised before use. The slight alkalinity of the sand was the cause of the higher *p*H value than in Table I.

Table III. *Plants of* Callitriche stagnalis *grown in three series of jars at different pH values, and inoculated with diseased roots of* Ranunculus aquatilis. *Planted April 14th, inoculated June 3rd, examined July 3rd.*

Plant No.	Mean *p*H value obs.	Infection obs.	Plant No.	Mean *p*H value obs.	Infection obs.	Plant No.	Mean *p*H value obs.	Infection obs.
D. 1	7	+[1]	D. 6	7	—	D. 11	10	—
D. 2	6	—	D. 7	7	—	D. 12	10	—
D. 3	6	—	D. 8	8	—	D. 13	10	—
D. 4	6	+[1]	D. 9	7	—	D. 14	10	—
D. 5	6	—	D. 10	7	—	D. 15	10	—

[1] In these jars there was very considerable growth and the resultant screening of the roots by the foliage may partly explain the presence of the fungus.

In this culture the roots of both the diseased plants and those used in the experiment were exposed to the light.

Tables I, II and III show several interesting results.

In Table I infected plants of *Callitriche stagnalis* after three months in the culture solution had entirely lost the fungus, with the exception of two plants in rather acid solutions.

In Table II after three weeks, ten plants out of sixteen of *Ranunculus aquatilis* were found to have contracted the fungus from infected plants of *Callitriche stagnalis*. The plants which did not become infected were, with one exception, growing in strongly alkaline solutions.

In Table III only two plants out of fifteen became infected and these were both growing in acid solutions, but owing to the abnormally dense growth of the plants the roots were to a large extent protected from the light.

In 1925 (4) using *Callitriche stagnalis* as inoculant the following results were obtained after two months:

Plantago major	10	plants	out of	10	became	infected
Poa annua	10	,,	,,	10	,,	,,
Mentha Pulegium	4	,,	,,	5	,,	,,
Ranunculus sp.	4	,,	,,	5	,,	,,
Iris Pseudacorus	8	,,	,,	10	,,	,,

Similarly using *Ranunculus aquatilis* as inoculant the results obtained were:

Plantago major	10	plants	out of	12	became	infected
Poa annua	4	,,	,,	5	,,	,,
Mentha Pulegium	3	,,	,,	3	,,	,,
Iris Pseudacorus	9	,,	,,	10	,,	,,

It is evident, therefore, that these plants can be successfully used as inoculants of the disease into other plants. The only difference between the two series of experiments was that while those in 1926 were carried out in open jars containing a culture solution those of the previous year were done in the soil itself.

From Table II it can be seen that infection of *Ranunculus aquatilis* by diseased roots of *Callitriche stagnalis* can occur in the course of about three weeks; also that plants in acid and neutral solutions become diseased while those in alkaline solutions do not. The series of experiments was sufficient to confirm the work of the previous year that the fungus can attack plants growing only in acid or neutral soils. The water at the pond at Sevenoaks is *p*H 5·5 or slightly acid. Further the *p*H value of the soil used in the inoculation experiments in 1925 was also slightly acid.

Series I and III differed from Series II in several features; in addition to a different host plant no silver sand was placed in the jars and the roots were in no way protected either from the sun or light. An examination of Tables I and III shows that with the exception of four plants no infection was obtained at the end of from three to four weeks. In 1925 when *Callitriche stagnalis* was used to inoculate a species of *Ranunculus* whose roots were growing in ordinary soil, infection was obtained in four plants out of five. These facts seem definitely to point to the conclusion that either the fungus cannot live and propagate in the presence of light, or that roots exposed to light are not suitable for the growth of *Ligniera*. This is further brought out by the fact that in Series I, in which thirty infected plants of *Callitriche stagnalis* were used, all with two exceptions, lost the fungus in about two months. These plants were also growing in jars without protection for the roots; control plants growing in large bell jars with soil at the bottom were still heavily infected after several months and showed no sign of losing the disease.

From these two series it is concluded that light is an inhibiting factor in the propagation of the fungus, and not only do roots which are exposed to light remain free from the fungus but also roots in which the disease is already present lose their infection in the course of a couple of months.

Discussion.

The resistance of plants to the attack of a parasitic fungus may be due, either to the absence from the host tissues of anything which is advantageous to the fungus, or to the presence in the cells of the host of some substance, or substances, which are definitely toxic to the parasite. In symbiotes it is probable that the former condition occurs, and that the host either directly or indirectly aids the fungus by the formation of substances which are definitely attractive to it. Generally, however, the resistance to fungal attack seems clearly to be due to the presence of something definitely poisonous to the fungus, which may either kill the parasite, or considerably curtail its activities.

In *Ligniera Junci* we have a fungus which can infect the cells of a great variety of aquatic or semi-aquatic plants, so long as the roots are protected from light. The fungus never invades tissues which are above the soil, consequently, when inoculation is attempted in plants with roots exposed to light, no disease is found. Furthermore when plants with abundant infection are planted in culture solutions with their roots uncovered the disease soon disappears. The natural conclusions are, either that those parts of the plant which are exposed, possess in their cells some substance, in the presence of which *Ligniera Junci* cannot grow, and since infected plants lose the disease, this substance not only prevents infection, but is sufficiently poisonous to kill the fungus even when it has gained a firm hold upon the host; or that light itself kills the fungus. It is considered quite probable that the substance which is toxic to the fungus is chlorophyll.

Other factors, however, besides light play an important part in controlling infection, for *Ligniera Junci* only infects plants growing in acid or neutral soils.

Atkins (2) found that in *Plasmodiophora Brassicae* the presence or absence of calcium was a more important factor than the relative acidity or alkalinity of the soil. He instances the case of two fields; the first, having a *p*H of 6·6 and 0·17 per cent. of calcium, was heavily infected with *Plasmodiophora Brassicae*; the second, having a *p*H of 6·7 and 0·40 per cent. of calcium, was free from disease. Here the relative acidity of the two fields can be neglected, and, assuming that there were no unrecorded

differences in the other constituents of the two soils, it would seem that the excess of soluble calcium in the soil of the second field was definitely toxic to the fungus. A liberal treatment of lime is universally recognised as a method of combating an attack of this disease, but it has generally been assumed that it was the alkalinity of the lime rather than the calcium which was the inhibiting factor.

In *Ligniera Junci* the inhibiting factor is the alkalinity and not the lime, since the quantity of calcium was the same in each culture jar.

Melhus, Rosenbaum and Schultz (6) found that in *Spongospora subterranea* lime increased the quantity of infection in the soil, and this is in general agreement with the work of other investigators on *Spongospora subterranea.*

Very little work has been done in this connection with the other genera of the Plasmodiophorales. *Sorosphaera Veronicae* differs from the other genera mentioned, in occurring in the green parts of the plant. Schwartz(3) found it particularly abundant in the green stem. Although no definite observations upon the physiological factors involved have been possible, plants of *Veronica Chamaedrys* infected with the fungus are most frequently found in the same localities as *Ligniera Junci.* So far it has not been found possible to carry out experiments with *Sorosphaera Veronicae.* Infected plants carefully removed and planted in the greenhouse free themselves from the fungus in a few months. I am told by Dr E. J. Schwartz that he has obtained the same results in plants which he tried to keep in his own greenhouse, but those which were planted in the garden remained infected for several years, although finally the disease disappeared. He has suggested to me that the life cycle of *Sorosphaera Veronicae* is completed very rapidly, and that the spores before germination have to pass through the alimentary tract of a slug or other animal, in order to make them capable of germination; he has, however, obtained no evidence to support this suggestion.

Mention must also be made of a recent paper by P. M. Jones (5). He describes a new and very interesting organism which he has provisionally called *Plasmodiophora Tabaci,* isolated from tobacco plants which were affected by mosaic-like symptoms. It would be out of place here to discuss the relations of this remarkable form. There are several points in the life cycle which do not conform to the general plan found in all the other genera, and there seems some doubt whether it should be considered to be a member of the Plasmodiophorales. It seems more likely that it is intermediate between the Plasmodiophorales and the Lobosa, which supports the view that the

Plasmodiophorales must have had an origin independent of the Mycetozoa, and it is unfortunate that the word "mycetozoan" should have been used in the title of the paper. The important feature of the species is that it lives in leaves, and far from being affected by the chlorophyll itself causes mosiac-like disease of the host leaves.

It would appear that the substance which controlled the infection was specific in *Ligniera Junci*. There is little or no relation between the different genera in their reaction to a particular substance. In *Plasmodiophora Brassicae* calcium seems to be the inhibiting factor, while in *Spongospora subterranea* excess of lime favours the growth of the fungus. Lime does not seem to affect *Ligniera Junci*, although alkalinity inhibits the disease. The effect of light on *Plasmodiophora Brassicae* or *Spongospora subterranea* has not been recorded, but it is definitely toxic to *Ligniera Junci*. On the other hand *Sorosphaera Veronicae* only occurs in tissues which are exposed to light.

The genera of the Plasmodiophorales which have been mentioned are remarkably similar in their life histories, yet in their responses to certain physiological stimuli they show diametrically opposite reactions. It is clear, therefore, that the response of a particular fungus to a series of physiological factors is of absolutely no value in deducing the reactions of any other fungus even if the two closely resemble one another in their general life cycles.

My thanks are due to Professor R. R. Gates for helpful criticism, and also to Dr E. J. Schwartz, who has allowed me to record in several places unpublished observations which he has made.

Summary.

1. Inoculation experiments with *Ligniera Junci* have been carried out to determine whether the relative acidity or alkalinity of the soil has any effect upon the quantity of infection.

2. With water-plants grown in an aqueous culture medium, infection is obtained in solutions of *p*H 5 to *p*H 8, when the roots are protected from the light by covering them with silver sand.

3. When plants are grown in a similar culture medium without any protection for the roots, no infection is obtained even at the optimum *p*H value.

4. Infected plants grown in aqueous culture media without protection of the roots from light lose the fungus in less than three months.

5. A comparison is made between the response of *Ligniera Junci* to the acidity of the soil and that recorded in other genera. Related genera are found to have quite different responses.

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STUDIES IN DISCOMYCETES. IV.

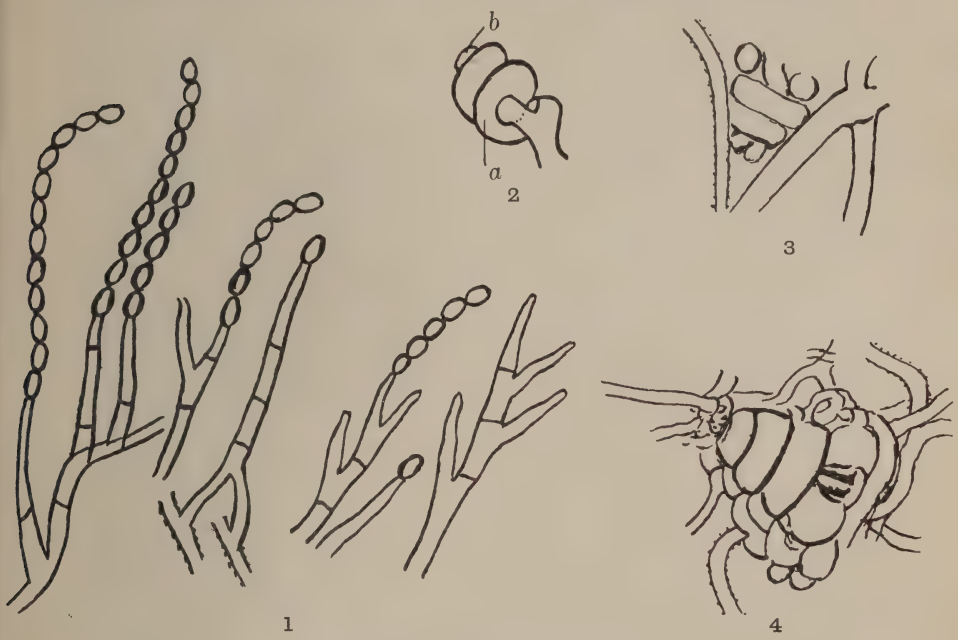
(With 4 Text-figs.)

By Jessie S. Bayliss Elliott, D.Sc. (Birmingham), B.Sc. (London).

Trichopeziza caesia (Pers.) Boud. This fungus, growing on a large chip of oak in my garden, showed conidia and primordial stages of the apothecia during August and September 1923. The conidia resembled those described and figured by Brefeld from cultures, being oval, unicellular and colourless 5–8 × 2·5–3μ (Brefeld's measured 5–8 × 3–4μ); they grew in very long streaming chains and developed basipetally, arising from simple or branched conidiophores (Fig. 1). The conidiophores appeared on the subiculum before the apothecia and continued to develop during early stages of apothecia formation.

For the examination of the primordia and early stages of apothecial development, microtome sections were made of material fixed in dilute ($\frac{1}{2}$ per cent.) chrom-acetic acid and stained with haematoxylin. An archicarp of the spiral type was present similar to that figured by Claussen (*Bot. Zeit.* lxiii, p. 1 (1905)) for *Ascodesmis nigricans* coiled round another hypha—presumably an antheridium (Fig. 2). Both hyphae were wider than ordinary vegetative hyphae and in one instance could be seen to have arisen as branches of a single bifurcating hypha (Fig. 2). No fusion was noted. A later stage showed the formation of a triangular shaped spiral of three or four turns (Figs. 3 and 4): this was followed by narrower hyphae from the vegetative hyphae around, growing up and surrounding the coiled primordial elements with a pseudoparenchymatous

sheath; thus a ball-like structure was formed looking very much like an ordinary cleistothecium of the *Sphaerotheca* type, from which branching and anastomosing hyphae began to extend outwards in all directions, thus giving the primordium the appearance of being enveloped in a thick layer of cotton wool. Meanwhile within this sheath, a hymenium of asci and paraphyses was formed; the details of development were not followed, owing to the very minute size of the elements concerned.



Trichopeziza caesia (Pers.) Boud.

Fig. 1. Conidia and conidiophores. × 800.
Fig. 2. Early stage in development of apothecium showing (*a*) coiled archicarp, and (*b*) antheridium. × 1500.
Fig. 3. Later stage drawn from microtomed material. × 1500.
Fig. 4. Young apothecium showing sterile hyphae beginning to form a sheath round an archicarp. Optical section. × 1500.

The hymenium becomes gradually exposed by the upward thrust of paraphyses bursting open the sheath and its woolly covering at the apex: the woolly covering persists for a time around the apothecium but sooner or later it dies away and a *Mollisia*-like apothecium is left seated on a subiculum composed of branching and anastomosing hyphae similar to the woolly sheath referred to above.

This fungus appeared again in the summer of 1924 on the same chip of wood, although no trace of it had been seen during

the winter of 1923–24. In July the conidial stage was very abundant and in August as soon as the piece of wood was placed in a little drier environment—in the open air but protected from rain—apothecia developed abundantly.

In Studies in Discomycetes III (*Trans. Brit. Mycol. Soc.* VII, p. 297, 1922) I referred to this fungus as *Mollisia caesia* (Fuckel) Sacc. thinking that "*Mollisia caesia* (Fuck.) Sacc. *Tapesia*" of Ramsbottom's list of British Discomycetes was synonymous with *Tapesia caesia* Fckl. as given by Massee; but it appears *Mollisia caesia* (Fuck.) Sacc. of the list is synonymous with *Niptera caesia* (Fuck.) (1871) and the fungus under consideration is really *Trichopeziza caesia* (Pers.) Boud. and is not included in Ramsbottom's list.

There seems to me however no reason why the fungus should not be retained in the genus *Tapesia*. Boudier includes in this genus species with apothecia of the *Mollisia* type which are growing on an abundant mycelium (subiculum) and, judging from the species he includes, this subiculum is usually brown but may be white, red or green. *Trichopeziza caesia* (Pers.) Boud. grows on a white subiculum and although the apothecium is surrounded by a sheath of anastomosing hairs in its immature condition, at maturity this disappears and the exterior is *Mollisia*-like; moreover the fungus while growing shows a course of development parallel to that of *Tapesia fusca* whose apothecia while immature possess a very similar hairy sheath disappearing at maturity.

Moreover, concerning the genus *Trichopeziza* in which he places the species under consideration Boudier says "beaucoup des espèces que je fais rentrer dans ce genre devront trouver place dans d'autres quand elles seront mieux connues."

Tapesia fusca (Pers.) Fuck. During several years I have watched the growth of the apothecia of this fungus which appears several times a year on a dead branch lying in my garden. The very young spherical apothecium before the hymenium is exposed is densely covered with anastomosing hairs, forming a woolly looking sheath; after the exposure of the hymenium this hairy sheath still persists around the excipulum. The hairs vary in colour from whitish to dark brown but they disappear eventually, leaving the apothecium looking like a typical *Mollisia* except that it is seated on a subiculum. The subiculum has always been well developed in material I have examined, though generally inconspicuous owing to its dark colour toning with that of the substratum—rotten oak wood—on which it was growing.

Humidity plays some part in the duration of the tomentose period of the apothecium, this being more prolonged if atmospheric conditions during the development are very damp. The

colour of the apothecia varied considerably, but although it included all ranges of honey-colour, grey or brown, apothecia were blue-grey when they had to a certain extent lost their hairy sheath and were still growing. The paraphyses were always well developed, about 2μ wide and aseptate. It will be seen that the development of this fungus is very similar to that described above for *Trichopeziza caesia*. In referring the fungus to its systematic position considerable difficulty was experienced because of its similarity at times to the closely allied *T. Rosae* (Pers.) Fuck., and *T. prunicola* Fuck.

Rehm though treating *T. prunicola* as a variety of *T. Rosae* remarks that he cannot see any essential difference between them and Massee treats both *T. prunicola* and *T. Rosae* as varieties of *T. fusca* and goes so far as to say that *T. Rosae* is scarcely to be considered a good variety of *T. fusca*.

A study of the descriptions of these species and an examination of material from the Kew Herbarium suggests that there is no essential difference between them. The tomentose exterior of *T. Rosae* and of *T. prunicola* seems the chief character which distinguishes them from *T. fusca* which is described as smooth.

Since the apothecia of *Tapesia fusca* show quite a prolonged tomentose period during their development, it seems to me not unreasonable to consider that *T. Rosae* and *T. prunicola* may be immature stages of *Tapesia fusca* the substrata, stems of *Rosa* and *Prunus* respectively, merely adding additional but not important distinction, for the Kew material includes specimens of *T. prunicola* from Sydow on *Spiraea* and *Calluna* and from Rehm on *Alnus*.

Tapesia lividofusca (Fr.) Rehm. In May 1921 I gathered this fungus at Borth. It is undoubtedly a *Tapesia* for a brown subiculum is present which is very dense where the apothecia are immature, though it becomes more scanty and even absent in the region of mature apothecia; further it is not unusual with other *Tapesia* spp. for the subiculum to disappear gradually, leaving only apothecia which are at that stage indistinguishable from those of the genus *Mollisia*.

It was first recorded for the country by Crossland (*Naturalist*, p. 5, 1904) under the name *Mollisia lividofusca* Gill. and is listed under that name by Ramsbottom. Although the spore measurements of my specimens approximate to those given by Rehm and Crossland they are invariably blunt, and not spindle-shaped or elliptic-fusiform as described respectively by these authors.

Rehm considers that *T. lividofusca* differs from *T. fusca* chiefly in that "ihr parenchymatisches, braunes Gehäuse bis zum Rande reicht, der auch niemals, besonders im trockenen Zustande, eingerollt ist." In my material the apothecia do show a rolling in of the margin; also the brown colour does not reach

to the rim, in fact the entire apothecium, not the hymenium only, appears very pale grey, or whitish yellow in contrast to the blue-grey appearance of *T. fusca* and moreover *T. lividofusca* seems altogether a more delicate structure than *T. fusca*.

Helotium lenticulare Fr. On examining material of this species, very kindly sent me by Miss Eyre (Aug. 1923) who found it growing on apple pulp, I was interested to find an apothecium in which the asci contained only four ascospores or sometimes fewer than four.

Pachyella depressa (Phill.) Boud. In May 1924 I received from Miss Eyre some very fine specimens of this fungus, which she had found growing on apple pulp. In these specimens the asci showed a very marked blue colour when treated with iodine.

Pachyella depressa (Phill.) Boud. var. ***pallida*** Rea. In May 1924 I received a collection of several apothecia which were referable to the species *Pachyella depressa*, except that they were pure white instead of amber brown, the only colour being a faint fuscous line round the margin. They were found growing on a log which had evidently been submerged for many months, perhaps years, in Barnt Green Reservoir (Worcestershire). A comparison with specimens of *P. depressa* from Porlock collected in the spring and autumn of 1920 indicated that the chief difference was the absence of colouring matter from the paraphyses and excipulum. Mr Rea kindly examined the specimen and agreed that it was a pale variety of *P. depressa* but considered it worthy of a varietal name—hence *P. depressa* var. *pallida*. The asci of this specimen do not give the blue reaction with iodine but I have gathered undoubted specimens of *P. depressa* which have not shown this reaction.

Hyalinia incarnata (Cooke) Boud. A specimen of this fungus was sent to me by Mr H. Bloom, May 1923. It was growing on a pine cone. Massee gives the substratum as pine leaves and remarks that the form and size of the spores were incorrectly described by Cooke and copied by Phillips and Saccardo. However, the spores of this specimen agreed with Cooke's description—linear, obtuse, hyaline, $10 \times 1{\cdot}5\mu$.

Other interesting Discomycetes I have received from Mr H. Bloom, are *Tapesia retincola* (Rabenh.) Karst. (May 1923) with spores slightly larger than either Rehm's or Crossland's measurements, being $18–23 \times 2{\cdot}5–3$ instead of $15–18 \times 2–2{\cdot}5$, also *Phialea bolaris* (Batsch) Quél. and *Plicaria Persoonii* (Cr.) Boud. (September 1924), all gathered at Mickleham, Surrey.

In conclusion I wish to express my indebtedness to Miss Wakefield for her kindness in consulting literature not available to me and to Miss Lorrain Smith and Mr J. Ramsbottom for advice on several fungi under criticism.

REVIEWS.

Iconographia Mycologica. By J. BRESADOLA. Milan: Società Botanica Italiana and Museo Civico di Storia Naturale di Trento. 8o.

All mycologists welcome the publication of this important work and rejoice in its being published under the auspices of the Società Botanica Italiana and the Museo Civico di Storia Naturale di Trento in celebration of the eightieth anniversary of the birth of the eminent Abbé The work will consist of one thousand plates with Latin diagnoses, including species of Hymenomycetae, Gasteromycetae and Discomycetae. Up to the present time two parts have been published of fifty plates each and it is proposed to complete the issue of the work within three years. The plates are excellent, giving both macroscopic and microscopic details, which will greatly facilitate the student in his identification of the species. From long experience I can say how helpful I have always found the beautiful plates Bresadola published in his *Fungi Tridentini*, with his accurate diagnoses, and I trust many of our members will subscribe to insure its completion. CARLETON REA.

The Microbiology of Cellulose, Hemicelluloses, Pectin and Gums. By A. C. THAYSEN and H. J. BUNKER. Pp. vii–363, tt. 9—five figs. in the text. Oxford: University Press. London: Humphrey Milford. 8o. 1927. 25*s.* net.

There is a wealth of mycological works now appearing presumably because there is a stabilisation of cost. The title of this book suggests that a gap has been filled in mycological literature, a gap which has proved somewhat troublesome to those who are lacking in chemical knowledge and moreover have not ready access to technical journals. It must be said however that the book is not satisfactory. The subject is admittedly difficult but the authors do not appear to have assimilated some at least of the information which they attempt to summarise, and some of the references given suffer from a failing that is becoming far too common in that a statement generally accepted is attributed to a recent author who happens to have mentioned it *en passant*. Over one hundred and thirty pages are occupied with a series of descriptions of bacteria and fungi which have been recorded as decomposing celluloses, etc. If the account is intended for reference it is neither in the right form nor complete enough; if not, a more general account would have been preferable. There is a suggestion of mere compilation, as if the authors have had no refining influence. There is a full synonymy of most of the species which in the form given is both unsatisfactory and misleading. The method of citation is often faulty. Time and again the authority is given in its wrong form, e.g. *Merulius lacrymans*, Wulfen.: Syn. *Boletus lacrymans*, Wulfen.; *Merulius lacrymans*, Schumacher. The method of double citation should be adopted or left alone. The recognised form is either *M. lacrymans* (Wulf.) Schum. or *M. lacrymans* Schum.

There is much information in the book that mycologists in general will welcome, but written in half the space it would have been of greater use.

J. R.

Enzymes: Properties, Distribution, Methods and Applications. By SELMAN A. WAKSMAN and WILBUR C. DAVISON. 8o. pp. xii, 364 with 10 text-figures. London: Baillière, Tindall and Cox, 1926. 25*s.* net.

The importance of enzymes in biological processes is at least as obvious to mycologists as to other workers. In the present volume we have the whole subject of enzymes presented in a concise form with an indication of the original

sources from which more detailed information can be obtained. Perhaps this conciseness will be criticised by some reviewers, but there is much to be said for such an uncommon characteristic; and when the source of the information is accurately given anyone interested in a particular aspect of a problem has all he needs, for abstracts and summaries, excellent in their way, are only second best. A notable feature of the book is the full list of references, over thirteen hundred in number. The work is divided into four sections. The first deals with the properties of enzymes, the historical development of our knowledge of enzymes, the part they play, their chemistry and reactions and the factors influencing their reactions. The distribution of enzymes is then treated, the last chapter of this section dealing with the enzymes of micro-organisms including bacteria and fungi. The following section will be found of great assistance to research workers for it gives clear well-arranged instructions for the preparation and study of enzymes, their properties, the measurement of their activity and so on. The final section is one which will appeal to those who are called upon as mycologists to advise or comment upon the peculiar ways of fungi for the practical applications of enzyme industry are chiefly due to these. Here may be found descriptions of the use of enzymes in textile industries, in tanning, in the preparation of "beverages"—surely a painful subject to the authors, in fruit clarification, food preparation, poultry breeding, tobacco ripening and a few others. The book is attractively printed and bound and has a satisfactory index. J. R.

Die Pilze Mitteleuropas. By F. KALLENBACH. Band I. Die Rohrlinge. (Boletaceae.) Lief. 3 and 4. Pp. 5–24, tt. 6. fol. Leipzig. Werner Klinkhardt. 1927. M. 10.

Two further fascicles of this work have appeared and are in every way up to the standard of the previous parts. As the text has now reached twenty-four pages we are able to gain a proper idea of the scope of the work for the whole is occupied with the very full description of seven of the species so far illustrated; a little more than two pages are devoted to the description of *B. rhodoxanthus* recorded by Mr Rea in the last number of the Transactions. The four additional coloured plates deal with *B. pseudosulphureus* Kallenb., which was described in 1923 from deciduous woods; *B. pulverulentus* Opat., which though not yet recorded for England, certainly occurs here; *B. rimosus* Vent. = *B. nigrescens* Roze and Richon; and *B. erythropus* Pers. non Fr. recorded in Rea's Basidiomycetae as *B. Queletii* var. *rubicundus*. The use of the name *B. erythropus* for different fungi has led to much confusion in the past. As Kallenbach realises, using it in the sense of Persoon is quite "illegal" according to the Brussels Code, but many of us are still not clear about the alternatives in fleshy fungi. If a reasonable nomenclature is adopted so that we can understand the results of so thorough a monograph we shall be better able to discuss the names having greater knowledge of the fungi. Two additional plates show photographs of five species and anatomical features of four.

J. R.

PROCEEDINGS, 1927

MEETING. UNIVERSITY COLLEGE, LONDON. *22nd January.*

W. Buddin and E. M. Wakefield. *Rhizoctonia Crocorum* (Pers.) DC. and *Helicobasidium purpureum* (Tul.) Pat.

R. C. Woodward. *Podosphaeria leucotricha*, the Apple Mildew.

K. Sampson. Anthracnose of Red Clover.

E. W. Mason. The naming of a dark-spored Hyphomycete.

J. Ramsbottom. Fragmenta Mycologica VI.

MEETING. UNIVERSITY COLLEGE, LONDON. *19th March.*

W. R. I. Cook. Influence of Environment on Infection of *Ligniera Junci.*

E. H. Ellis. Fungi in Japanese Carvings.

E. W. Fenton. Seed Mixtures and the Incidence of Fungal Diseases.

M. P. Hall. Zoning in Cultures of *Monilia fructigena.*

K. R. Mohendra. Varieties in *Sphaeropsis Malorum.*

J. Ramsbottom. Fragmenta Mycologica. VII.

SPRING FORAY FOR LONDON STUDENTS. WISLEY. *7th May.*

SPRING FORAY. MARLBOROUGH. *June 3rd—6th.*

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13. Barr, Rev. Robert, T.D., M.A., The Manse, Neilston, Renfrewshire. (1918.)
14. Barrington, Dr F. J. F., University College Hospital, Medical School, University Street, London, W.C. 1. (1901.)
15. Bartlett, Mr A. W., M.A., B.Sc., Department of Botany, Armstrong College, Newcastle-on-Tyne. (1920.)
16. Bates, Mrs L. F., 82, Lordship Park, Stoke Newington, London, N. 16. (1921.)

17. Beaumont, Mr Albert, B.A., Seale-Hayne Agricultural College, Newton Abbot, Devon. (1924.)
18. Bewley, Mr W. F., D.Sc., Experimental and Research Station, Cheshunt, Herts. (1922.)
19. Biffen, Professor Sir Rowland H., M.A., F.R.S., 136, Huntingdon Road, Cambridge. (1899.)
20. Birmingham Natural History and Philosophical Society, c/o G. T. Calvert, Esq., Hon. Librarian, Avebury House, 55, Newhall Street, Birmingham. (1920.)
21. Bisby, Mr Guy R., Ph.D., Manitoba Agricultural College, Winnipeg, Canada. (1921.)
22. Blackman, Professor V. H., M.A., F.R.S., Imperial College of Science, South Kensington, London, S.W. 7. (1900.)
23. Blackwell, Miss Elsie M., M.Sc., Botanical Department, Royal Holloway College, Englefield Green, Surrey. (1917.)
24. Blagden, Mr C. O., 57, Earl's Court Square, London, S.W. 5. (1910.)
25. Bloom, Mr James Harvey, M.A., 123 Drakefield Road, Balham, London, S.W. 17. (1915.)
26. Bolas, Mr B. D., 60, Grove Park Terrace, Chiswick, London, W. 4. (1924.)
27. Borthwick, Professor A. W., D.Sc., Forestry Department, The University, Aberdeen. (1911.)
28. Boston, The Mycological Club, c/o Miss Jennie F. Conant, 26, Prospect Street, Melrose, Mass., U.S.A. (1906.)
29. Boyd, Mr D. A., St Clair, Caledonia Road, Saltcoats, N.B. (1906.)
30. Bracher, Miss Rose, M.Sc., Botanical Department, The University, Bristol. (1922.)
31. Braid, Professor K. W., B.A., B.Sc., West of Scotland Agricultural College, 6, Blythswood Square, Glasgow. (1922.)
32. Brazier, Mr E., Ty'n-y-gongl, Love Lane, Stourbridge. (1921.)
33. Breeze, Miss B. M., B.Sc., School of Agriculture, Cambridge. (1922.)
34. Brenchley, Mr G. H., B.A., Clare College, Cambridge. (1925.)
35. Brett, Miss M., M.Sc., Northern Polytechnic, Holloway Road, London, N. 7. (1921.)
36. Briant, Mr A. K., B.A., Shalbourne Mills, Hungerford, Berks. (1927.)
37. Brierley, Mr W. B., D.Sc., F.R.A.I., F.L.S., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919.)
38. Bright, Mr T. B., The Cove, Silverdale, Carnforth, Lancs.
39. British Museum, The Trustees of, Cromwell Road, South Kensington, London, S.W. 7. (1914.)
40. Briton-Jones, Professor H. R., Ph.D., D.I.C., A.R.C.S., Imperial College of Tropical Agriculture, St Augustine, Trinidad, B.W.I. (1923.)

41. Brittlebank, Mr C. C., Produce Offices, 607, Flinders Street, Melbourne, Victoria, Australia. (1921.)
42. Brooks, Mr F. T., M.A., The Botany School, Cambridge. (1907.)
43. Brown University, Library, East Side Station, Providence, R.I., U.S.A. (1920.)
44. Brown, Mr W., M.A., D.Sc., Imperial College of Science, South Kensington, London, S.W. 7. (1922.)
45. Bruxelles, Jardin Botanique de l'État, c/o M. P. van Aerdschot. (1911.)
46. Bryce, Mr G., D.Sc., Director, Rubber Research Institute, Kuala Lumpur, Federated Malay Straits. (1915.)
47. Buckley, Mr W. D., "Lynmouth," 2, Curzon Street, Slough. (1916.)
48. Buddin, Mr Walter, M.A., Laboratory of Plant Pathology, University of Reading, 7, Redlands Road, Reading. (1921.)
49. Buller, Professor A. H. R., D.Sc., Ph.D., F.R.S.C., University of Manitoba, Winnipeg, Canada. (1911.)
50. Bunker, Mr H. J., B.A., St Olave's, Churchfield Road, Poole, Dorset. (1925.)
51. Bunting, Mr R. H., F.L.S., Agricultural Department, Aburi, Gold Coast Colony, West Africa. (1921.)
52. Bunyard, Mr G. N., F.L.S., 25, Bower Mount Road, Maidstone, Kent. (1920.)
53. Burger, Dr O. F., Agricultural Experiment Station, Gainesville, Florida, U.S.A. (1925.)
54. Burr, Mr S., The Agriculture Department, The University, Leeds. (1924.)
55. Butcher, Mr R. W., B.Sc., Fisheries Research Station, Alresford, Hants. (1922.)
56. Butler, Mr E. J., C.I.E., D.Sc., F.R.S., M.B., F.L.S., Imperial Bureau of Mycology, 17, Kew Gardens, Kew, Surrey. (1920.)
57. Butler, Mr R. R., M.Sc., A.I.C., Chemical Department, Municipal Technical School, Plymouth, Devon. (1924.)
58. Cadman, Miss E. J., 5, Goldenacre Terrace, Edinburgh. (1921.)
59. Cambridge, The Botany School. (1920.)
60. Cape Town, Union of South Africa, The Mycologist (91410), Department of Agriculture. (1922.)
61. Carr, Professor J. W., M.A., University College, Nottingham. (1896.)
62. Carrothers, Mr E. N., 145, Stranmillis Road, Belfast, N. Ireland. (1925.)
63. Cartwright, Mr K. St G., B.A., New House Farm, Hughenden, Bucks. (1913.)
64. Castellani, Professor Aldo, C.M.G., M.D., 33, Harley Street, London, W. 1. (1922.)

65. Cayley, Miss Dorothy M., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1913.)
66. Chapman, Mr A. Chaston, F.R.S., F.I.C., Chemical Laboratories, 8, Duke Street, London, E.C. 3. (1926.)
67. Charles, Mr J. H. V., Biochemical Laboratory, Ardeer Factory, Nobel's Explosives Co., Ltd., Stevenston, Ayrshire. (1922.)
68. Chaudhuri, Mr H., M.Sc., Ph.D., University of the Punjab, Lahore, India. (1920.)
69. Cheal, Mr W. F., Kirton Agricultural Institute, Kirton, Nr Boston, Lincs. (1927.)
70. Cheel, Mr Edwin, Botanic Gardens, Sydney, New South Wales, Australia. (1919.)
71. Ciferri, Dr R., Director, Estacion Nacional Agronomica y Colegio de Agricultura, Moca, Dominican Republic, W.I. (1926.)
72. Cleland, Mr J. Burton, M.D., Professor of Pathology, University of Adelaide, South Australia. (1918.)
73. Clement, Mr E., 189, Upper Grosvenor Road, Tunbridge Wells, Kent. (1927.)
74. Collett, Mr R. Leslie, M.A., 12, Hereford Mansions, Bayswater, London, W. 2. (1921.)
75. Cook, Mr W. R. I., Ph.D., Priory Lodge, Newlands Park, Sydenham, London, S.E. 26. (1924.)
76. Cooper, Miss Charlotte A., California Lane, Bushey Heath, Herts. (1911.)
77. Copenhagen, Universitets-Bibliothek, c/o P. Haase & Son, Løvstraede 8, København K., Denmark. (1923.)
78. Cornell University, The Library, New York State College of Agriculture, Ithaca, N.Y., U.S.A. (1920.)
79. Corner, Mr E. J. H., Sidney Sussex College, Cambridge. (1924.)
80. Cory, Mr F. M., Botanical Department, The University, Bristol. (1926.)
81. Cotton, Mr Arthur D., F.L.S., Keeper, Herbarium, Royal Botanic Gardens, Kew, Surrey. (1902.)
82. Crawford, Miss J. M., The Vicarage, Lyford Road, Wandsworth Common, London, S.W. 18. (1926.)
83. Crow, Mr W. B., M.Sc., F.L.S., Botanical Department, University College, Cardiff. (1921.)
84. Cunningham, Mr G. H., Biological Laboratory, 71, Fairlie Terrace, Kilburn, Wellington, New Zealand. (1922.)
85. Curator, National Collection of Type Cultures, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
86. Curtis, Miss Kathleen M., M.A., D.Sc., D.I.C., F.L.S., Mycologist, Biological Department, Cawthron Institute of Scientific Research, Nelson, New Zealand. (1917.)
87. Cutting, Mr E. M., M.A., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1920.)

88. Darbishire, Professor O. V., B.A., Ph.D., F.L.S., The University, Bristol. (1913.)
89. Das, Mr Kedarnath, C.I.E., M.D., Principal, Carmichael Medical College, 1, Belgachia Road, Calcutta, India. (1922.)
90. Davies, Mr D. W., B.Sc., Adviser in Mycology, Agricultural Buildings, University College of Wales, Aberystwyth. (1923.)
91. Davis, Mr J. Jefferson, B.S., M.D., University of Wisconsin, Madison, Wis., U.S.A. (1921.)
92. Day, Mr E. Metcalfe, Rowan Cottage, Minchinhampton, Glos. (1921.)
93. Deighton, Mr F. C., B.A., Mycologist, Department of Lands and Forests, Freetown, Sierra Leone, West Africa. (1925.)
94. Dickinson, Mr S., 3, The Warren, Lillington, Leamington Spa. (1921.)
95. Dickson, Professor B. T., B.A., Ph.D., Macdonald College, St Anne de Bellevue, Quebec, Canada. (1923.)
96. Diggle, Major P. G. W., c/o National Bank of Egypt, 6, King William Street, London, E.C. (1926.)
97. Dodge, Dr Carroll W., Farlow Herbarium, 20, Divinity Avenue, Cambridge, 38, Mass:, U.S.A. (1926.)
98. Dowson, Mr W. J., M.A., F.L.S., Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey. (1920.)
99. Doyle, Professor J., M.Sc., University College, Dublin. (1925.)
100. Duke, Miss M. M., B.Sc., Herbarium, Royal Botanic Gardens, Kew, Surrey. (1924.)
101. Edwards, Mr W. H., Curator, The Museum, Birmingham. (1896.)
102. Elliot, Rev. E. A., Dunstall Vicarage, Burton-on-Trent. (1923.)
103. Elliott, Mr W. T., D.D.S., L.D.S., F.L.S., F.Z.S., Arden Grange, Tanworth-in-Arden, Warwickshire. (1913.)
104. Elliott, Mrs J. S. Bayliss, D.Sc. (B'ham), B.Sc. (Lond.), Arden Grange, Tanworth-in-Arden, Warwickshire. (1911.)
105. Ellis, Mr David, D.Sc., Ph.D., F.R.S.E., Royal Technical College. (1923.)
106. Ellis, Mr E. H., British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7. (1924.)
107. Ellis, Mr Holmes, F.R.M.S., 23, Townley Street, Colne, Lancs. (1927.)
108. Engledow, Mr F. L., M.A., School of Agriculture, Cambridge. (1922.)
109. Essex Field Club, c/o Mr Percy Thompson, F.L.S., Essex Museum of Natural History, Romford Road, Stratford, London, E. 15. (1919.)
110. Exeter, Librarian, University College of the South-West of England. (1926.)

111. Eyre, Miss J. C., Maitlands Cottage, Ipplepen, Newton Abbot, Devon. (1915.)
112. Fenton, Mr E. W., M.A., B.Sc., F.L.S., Botanical Department, Seale Hayne Agricultural College, Newton Abbot, Devon. (1920.)
113. Finlayson, Mr Raymond A., F.L.S., Official Seed Testing Station, Huntingdon Road, Cambridge. (1910.)
114. Fry, Miss E. J., "Hazelhurst," Pear Tree Avenue, Bitterne, Southampton. (1923.)
115. Gadd, Mr C. H., D.Sc., Tea Research Institute, Nuwara Eliya, Ceylon. (1921.)
116. Gardner, Capt. Frederic, c/o Lloyd's Bank, Jersey, C.I. (1898.)
117. Garside, Mr S., M.Sc., F.L.S., Botanical Department, Bedford College, Regent's Park, London, N.W. 1. (1922.)
118. Gates, Professor R. R., B.Sc., Ph.D., F.L.S., King's College, Strand, London, W.C. (1921.)
119. Gilbert, M. E., Docteur en Pharmacie, 6, Rue de Laos, Paris (15e), France. (1924.)
120. Gilbert, Dr E. M., Botanical Department, University of Wisconsin, Madison, Wis., U.S.A. (1922.)
121. Gilchrist, Miss Grace G., B.Sc., Botanical Department, The University, Bristol. (1921.)
122. Gorman, Mr M. J., A.R.C.Sc.I., College of Science, Upper Merrion Street, Dublin. (1925.)
123. Gossling, Mrs W. L., 20, Carlton Hill, London, N.W. 8. (1922.)
124. Gough, Mr G. C., B.Sc., A.R.C.S., Ministry of Agriculture, Birmingham. (1923.)
125. Gould, Mr F. G., Elmhurst, Church Hill, Loughton, Essex. (1918.)
126. Green, Col. C. Theodore, A.M.S., M.R.C.S., L.R.C.P., F.L.S., 31, Shrewsbury Road, Birkenhead. (1901.)
127. Green, Miss E., 9, Brunswick Square, London, W.C. (1925.)
128. Green, Mr E. Ernest, F.Z.S., F.E.S., Way's End, Camberley, Surrey. (1917.)
129. Grey, Mrs O., F.Z.S., 90, Charing Cross Road, London, W.C. 2. (1926.)
130. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, London, S.E. 18. (1913.)
131. Gunter, Mr Thomas J., 4, Alexandra Road, London, N. 4. (1926.)
132. Gwynne-Vaughan, Professor Dame Helen, D.Sc., LL.D., F.L.S., 93, Bedford Court Mansions, London, W.C. 1. (1906.)
133. Haas, Mr P., D.Sc., Ph.D., F.C.S., University College, Gower Street, London, W.C. 1. (1921.)
134. Hanna, Mr W. F., M.Sc., University of Alberta, Edmonton, Alberta, Canada. (1925.)

135. Hansford, Mr C. G., M.A., Mycologist, Department of Agriculture, Kampala, Uganda. (1921.)
136. Harvard University, The Library, Cambridge, Mass., U.S.A. (1923.)
137. Hare, Mr J. G., Molteno Institute of Parasitology, Cambridge. (1924.)
138. Harris, Mr R. V., B.Sc., Horticultural Research Station, East Malling, Kent. (1924.)
139. Harvey, Mrs Cecily D., Barwick-in-Elmet Rectory, near Leeds. (1910.)
140. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1. (1913.)
141. Hemmi, Dr Takewo, Phytopathological Institute, Department of Agriculture, Kyoto Imperial University, Kyoto, Japan. (1923.)
142. Hildyard, Mr F. W., 14, Lambridge, Bath. (1913.)
143. Hiley, Mr Wilfred E., M.A., F.L.S., Research Institute, School of Forestry, Oxford. (1913.)
144. Hoare, Mr A. H., 111, Blenheim Gardens, Wallington, Surrey. (1922.)
145. Hoggan, Miss I. A., Department of Plant Pathology, University of Wisconsin, Madison, Wis., U.S.A. (1923.)
146. Holden, Dr H. S., F.L.S., Botanical Department, University College, Nottingham. (1923.)
147. Honolulu, The Library, Experiment Station, S.P.A., Box 411, Hawaii. (1920.)
148. Horne, Mr A. S., D.Sc., F.L.S., F.G.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
149. Howard, Mr H. J., F.R.M.S., "Lingfield," 6, College Road, Norwich. (1918.)
150. Howarth, Mr W. O., M.Sc., Botanical Department, The University, Manchester. (1927.)
151. Hughes, Mr G. C., Chesterton, Bicester, Oxon. (1898.)
152. Hughes, Mr J. S., 67, Woodstock Road, Oxford. (1927.)
153. Humphrey, Mr C. J., Mycologist and Plant Pathologist, Bureau of Science, Manila, Philippine Islands. (1921.)
154. Hurrell, Mr H. E., 25, Regent Street, Great Yarmouth. (1921.)
155. Hyde, Mr H. A., M.A., F.L.S., National Museum of Wales, Cardiff. (1924.)
156. Imperial College of Tropical Agriculture, Trinidad, B.W.I. (1921.)
157. Iowa, The Library, State University of Iowa, Iowa City, U.S.A. (1923.)
158. Iowa State College, Library, Ames, Iowa, U.S.A. (1927.)
159. Issatchenko, Professor B. L., Directeur du Jardin Botanique, Petrograd. (1923.)

160. Jaczewski, Professor Arthur de, Director, Institute of Mycology and Phytopathology, Perspective Anglaise 29, Petrograd, Russia. (1922.)
161. John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1924.)
162. Johnson, Mr J. W. Haigh, M.Sc., F.I.C., F.L.S., Walton, near Wakefield. (1919.)
163. Johnstone, Miss K. H., B.A., All Saints' Vicarage, Cheltenham, Glos. (1927.)
164. Johnstone, Mr R. B., 3, Oswald Gardens, Scotstounhill, Glasgow. (1908.)
165. Jones, Mr G. H., M.A., Department of Agriculture, Ibadan, South Nigeria. (1922.)
166. Jones, Mr Robert Fowler, Trinity House, Denton Road, Ilkley, Yorks. (1918.)
167. Jørstad, Mr Ivar, Statsmykolog, Botanisk Museum, Christiania, Norway. (1923.)
168. Kavina, Professor Dr Karel, Professor of Botany, Havlickovy-sady 58, Praha-Kral. Vinohrady (Prague), Czechoslovakia. (1926.)
169. Keef, Miss Phoebe, Mortimer Lodge, Wimbledon Park, London, S.W. 17. (1921.)
170. Keilin, Dr D., Molteno Institute of Parasitology, Cambridge. (1922.)
171. Keissler, Dr Karl, Direktor d. Botanischen Abteilung, Naturhistorisches Museum, Burgring 7, Wien 1/1, Austria (1924.)
172. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921.)
173. Kendall, Miss Olwen, 9, Lordship Park, Stoke Newington, London, N. 16. (1921.)
174. Kew, The Library, Royal Botanic Gardens. (1921.)
175. Kidd, Mrs Franklin, B.A., The Botany School, Cambridge. (1919.)
176. Kirby, Mr E. E., B.A., Grafton House, Oxford Street, Norwich. (1924.)
177. Klika, Mr Bohumil, Hálkova 37, Prague, Vrsovice 553, Czechoslovakia. (1926.)
178. Knight, Mr H. H., M.A., The Lodge, All Saints' Villas, Cheltenham. (1914.)
179. Knowles, Miss M. C., M.R.I.A., Natural History Museum, Dublin. (1925.)
180. Krieger, Mr L. C. C., 2114, N. Calvert Street, Baltimore, Md., U.S.A. (1921.)
181. Kulkarni, Mr G. S., M.Ag., Cotton Research Laboratory, Dharwar, India. (1922.)

182. Lampitt, Mr L. H., D.Sc., F.I.C., Thornlea, Mount Park, Harrow, Middlesex. (1925.)
183. Latter, Miss Joan, Botanical Department, King's College, Strand, London, W.C. 2. (1923.)
184. Leicester, The Museum, City of Leicester. (1923.)
185. Lewis, Professor F. J., D.Sc., University of Alberta, Edmonton, Alberta, Canada. (1924.)
186. Line, Mr James, M.A., School of Agriculture, Cambridge. (1921.)
187. Linnean Society, The, Burlington House, Piccadilly, London, W. 1. (1919.)
188. Lloyd Library, The, Cincinnati, Ohio, U.S.A.
189. Lowndes, Mr A. G., M.A., Marlborough College, Marlborough, Wilts. (1922.)
190. MacCallum, Mrs B. D., M.A., D.Sc., F.L.S., c/o Professor MacCallum, Department of Pathology, University of Melbourne, Australia. (1921.)
191. Mackenzie, Miss A. D., Research Station, East Malling, Kent. (1921.)
192. Mackenzie, Mr D., . (1900.)
193. Madras University Library, Madras, South India. (1925.)
194. Maire, M. René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algers, Algeria, N. Africa. (1907.)
195. Maltby, Mr G. C., 14, Northwick Road, Evesham. (1923.)
196. Marriott, Mr St John, 37, Owenite Street, Abbey Wood, London, S.E. 2. (1920.)
197. Marsh, Mr R. W., M.A., Research Station, Long Ashton, Bristol. (1923.)
198. Martyn, Mr E. B., B.A., 27, Belgrave Road, London, S.W. 1. (1927.)
199. Mason, Mr E. W., M.A., M.Sc., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1921.)
200. Mason, Mrs E. W., Suffield House, Paradise Road, Richmond, Surrey. (1922.)
201. Mason, Mr F. A., F.R.M.S., M.S.P.A., 29, Frankland Terrace, Leeds. (1912.)
202. Matthews, Mr J. R., M.A., F.L.S., Royal Botanic Gardens, Edinburgh. (1921.)
203. Mehta, Professor K. C., Ph.D., Department of Biology, Agra College, Agra, U.P., India. (1921.)
204. Melvill, Mr J. Cosmo, M.A., D.Sc., F.L.S., Meole Brace Hall, Shrewsbury. (1922.)
205. Menzies, Mr James, 117, Scott Street, Perth. (1917.)
206. Metcalfe, Mr C. R., The Hirsel, Broadstone, Dorset. (1926.)
207. Meulenhoff, Dr J. S., President, Dutch Mycological Society, Diezerstraat, Zwolle, Holland. (1921.)

208. Michigan Agricultural College Library, East Lansing, Michigan, U.S.A. (1924.)
209. Millard, Mr W. A., B.Sc., The Agriculture Department, The University, Leeds. (1924.)
210. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902.)
211. Miyabe, Dr Kingo, Professor of Botany, Hokkaido Imperial University, Sapporo, Japan. (1919.)
212. Mohendra, Mr K. R., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1927.)
213. Montague, Mrs A., Penton, Crediton, N. Devon. (1898.)
214. Moore, Miss E. S., Ph.D., c/o the Secretary, Department of Agriculture, P.O. Box 994, Pretoria, South Africa. (1923.)
215. Moore, Mr W. C., M.A., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1922.)
216. Morris, Mr L. E., The Shirley Institute, Didsbury, Manchester. (1924.)
217. Moss, Professor C. E., The University, P.O. Box 1176, Johannesburg, South Africa. (1923.)
218. Mottram, Miss W. E., B.Sc., Horton Lane, Epsom, Surrey. (1925.)
219. Mundkur, Mr B. B., M.A., Cotton Research Laboratory, Government Farm, Dharwar, India. (1924.)
220. Murphy, Mr P. A., Sc.D., A.R.C.Sc.I., M.R.I.A., Plant Diseases Division, College of Science, Upper Merrion Street, Dublin. (1924.)
221. Murray, Mr G. H., F.E.S., Papuan Government Service, Port Moresby, Papua, British New Guinea. (1921.)
222. Murrell, Major Percy J., O.B.E., F.R.M.S., "Littlecroft," Orpington, Kent. (1923.)
223. Muskett, Mr A. E., B.Sc., A.R.C.S., Queen's University, Belfast, North Ireland. (1923.)
224. McDonald, Mr J., B.Sc., Mycologist, Department of Agriculture, Box 323, Nairobi, Kenya Colony, East Africa. (1923.)
225. McDougall, Professor W. B., University of Illinois, Urbana, Ill., U.S.A. (1921.)
226. McFarland, Dr Frank T., Department of Botany, University of Kentucky, Lexington, Ky., U.S.A. (1924.)
227. McLean, Professor R. C., M.A., D.Sc., F.L.S., Botany School, University College, Cardiff. (1922.)
228. McLennan, Dr Ethel I., Botanical Department, Melbourne University, Carlton, Victoria, Australia. (1926.)
229. Nagpur, The Mycologist to the Government, C.P., India. (1924.)
230. Nattrass, Mr R. M., B.Sc. (Agric.), Research Station, Long Ashton, Bristol. (1925.)
231. Nebraska, The Library, University of, Lincoln, Nebr., U.S.A. (1924.)

232. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Zoomweg 10, Wageningen, Holland. (1920.)
233. Newcastle-upon-Tyne, Literary and Philosophical Society, c/o Mr H. Richardson, Librarian. (1902.)
234. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904.)
235. Nicholson, Mr W. E., F.L.S., 50, St Anne's Crescent, Lewes. (1913.)
236. Noel, Miss E. F., F.L.S., 37, Moscow Court, Queen's Road, London, W. 2. (1913.)
237. Norman, Mr L. Stafford, Korigeni Estate, Luchenza P.O., Nyasaland. (1927.)
238. North Carolina, Library, University of, Chapel Hill, North Carolina, U.S.A. (1920.)
239. Nursery and Market Garden Industries' Development Society, Ltd., Experimental and Research Station, Cheshunt, Herts. (1922.)
240. Nutman, Mr F. J., B.Sc., A.R.C.S., Imperial Forestry Institute, Oxford. (1926.)
241. O'Connor, Mr P., B.Sc., A.R.C.Sc.I., College of Science, Upper Merrion Street, Dublin. (1925.)
242. Ogilvie, Mr L., M.A., M.Sc., Department of Agriculture, Agricultural Station, Paget East, Bermuda. (1922.)
243. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove, Sussex. (1908.)
244. Oldham, Mr C. H., Ivy Dene, Chandler's Ford, Southampton. (1923.)
245. Ontario Agricultural College, Library, Guelph, Ontario, Canada. (1920.)
246. Osborn, Professor T. G. B., M.Sc., Adelaide University, Adelaide, South Australia. (1910.)
247. Ottawa, Ontario, Canada, The Library, Geological Survey. (1926.)
248. Overeem, Dr C. van, Mycologisches Museum, Weesp, Holland. (1920.)
249. Page, Miss W. M., B.Sc., 19, Ledam Buildings, Bourne Estate, Holborn, London, E.C. 1. (1921.)
250. Pan, Mr T. C., M.B., Ch.B., Red Cross Hospital, 263 Avenue Haig, Shanghai, China. (1925.)
251. Parke Davis & Co., Librarian, Research Department, Detroit, Michigan, U.S.A. (1920.)
252. Paul, The Very Rev. David, D.D., LL.D., 53, Fountainhall Road, Edinburgh. (1899.)
253. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Middlesex. (1918.)
254. Peacock, Dr H. G., The Lawn, Torquay. (1896.)

255. Pearson, Mr Arthur A., F.L.S., 59, Southwark Street, London, S.E. 1. (1911.)
256. Peklo, Dr Jaroslav, Professor of Applied Botany, Bohemian Technical University, Charles Square, Prague II, Czechoslovakia. (1924.)
257. Perthshire Society of Natural Science, c/o Mr James Winter (Hon. Treasurer), 35, George Street, Perth. (1919.)
258. Petch, Mr T., B.A., B.Sc., Tea Research Institute, Nuwara Eliya, Ceylon. (1911.)
259. Pethybridge, Mr G. H., Ph.D., B.Sc., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
260. Philadelphia, The Academy of Natural Sciences of Philadelphia, Logan Square, Phila., U.S.A. (1925.)
261. Phillips, Dr H. H., 6, St John's Road, Penge, London, S.E. 10. (1923.)
262. Phillips, Mr F. J., Research Officer, Forest Research Station, Deepwalls, Knysna, South Africa. (1921.)
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276. Rea, Miss M. W., M.Sc., Salem House, Sydenham, Belfast, Ireland. (1920.)
277. Rea, Miss Violet, 6, Barbourne Terrace, Worcester. (1921.)

278. Reichert, Dr Israel, Plant Pathologist, Palestine Zionist Executive Agricultural Experiment Station, Tel-Aviv, Palestine. (1924.)
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287. Roper, Miss Ida M., F.L.S., 4, Woodfield Road, Redland, Bristol. (1921.)
288. Rothamsted Experimental Station, Department of Mycology, Harpenden, Herts. (1923.)
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303. Sharples, Mr A., A.R.C.S., D.I.C., Mycologist, Department of Agriculture, Kuala Lumpur, Federated Malay States. (1924.)
304. Shaw, Mr F. J. F., D.Sc., A.R.C.S., F.L.S., Imperial Agricultural Research Institute, Pusa, Bihar, India. (1920.)
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322. Swansea Field Naturalists' Society, c/o Mr Alan Stuart, M.Sc., University College, Singleton, Swansea, South Wales. (1924.)

323. Swanton, Mr E. W., A.L.S., Educational Museum, Haslemere, Surrey. (1899.)
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343. Washington, Library, State College of Washington, Pullman, Wash., U.S.A. (1924.)
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346. Westerdijk, Professor Johanna, Javalaan 4, Baarn, Holland. (1923.)

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351. Williamson, Mrs H. S., B.Sc., 3, Verulam Buildings, Gray's Inn, London, W.C. 1. (1921.)
352. Wilson, Mr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
353. Wilson, Miss M. J., B.Sc., 23, Hoseside Road, Wallasey, Cheshire. (1927.)
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355. Wiltshire, Mrs S. P., 24, Lawn Crescent, Kew Gardens, Surrey. (1925.)
356. Winsor, Mr A. P., A.R.C.Sc.I., Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1. (1923.)
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360. Woodward, Mr R. C., Ph.D., School of Rural Economy, Oxford. (1924.)
361. Woolhope, The Naturalists' Field Club, Hereford, c/o Col. M. J. G. Scobie, 2, Offa Street, Hereford. (1896.)
362. Worcestershire Naturalists' Field Club, c/o Mr W. J. Else, Victoria Institute, Worcester. (1921.)
363. Wormald, Mr H., D.Sc., A.R.C.S., Research Station, East Malling, Kent. (1921.)
364. Wright, Mr E. Barton, B.Sc., Oakleigh, Godstone, Surrey. (1926.)

RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its objects shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct. 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous Year.

Meetings.

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

APPENDIX.

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of .....

.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

.....

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